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Türkiye's Net Zero Emission Target: Road Map for Transport

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02.03.2026

REPUBLIC OF TÜRKİYE
MINISTRY OF TRANSPORT
AND INFRASTRUCTURE

SECTORAL
OPERATIONAL
PROGRAMME FOR
TRANSPORT

NET ZERO
EMISSION IN
TRANSPORT

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LIST OF ABBREVIATIONS

AI	Artificial Intelligence
AIREG	The Aviation Initiative for Renewable Energy in Germany
APU	Auxiliary Power Units
AVE	Spain's high-speed rail network
BAPPENAS	Indonesia's National Development Planning Agency
BAU	Business As Usual
BCR	Benefit/Cost Ratio
BEVs	Battery Electric Vehicles
BlmSchV	Bundes-Immissionsschutzverordnung
BRI	Belt and Road Initiative
BRT	Bus Rapid Transit
CAEP	Committee on Aviation Environmental Protection
CBAM	Carbon Border Adjustment Mechanism
CCMSAP	Climate Change Mitigation Strategy and Action Plan
CCS	Carbon Capture and Storage
CCUS	Carbon Capture Utilization And Storage
CEM	Clean Energy Ministerial
CH4	Methane
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
CSOs	Civil Society Organizations
DIN	Deutsches Institut für Normung
DKK	Danish Krone
EBRD	European Bank for Reconstruction and Development
ECAs	Emission Control Areas
EEG	Renewable Energy Sources Act
EFS	EU Effort Sharing Regulation
EGD	European Green Deal
EN	Europäische Norm
EPA	U.S. Environmental Protection Agency
ERA	European Union Agency for Railways
eSAF	Synthetic Sustainable Aviation Fuel
EU	European Union
EUR	Euro
EVs	Electric Vehicles

GDP	Gross Domestic Product
GFEI	Global Fuel Economy Initiative
GHG	Greenhouse Gas
GVFG	Municipal Transport Financing Act
HC	Hydrocarbons
ICAO	International Civil Aviation Organization
ICE	Internal Combustion Engine
IDAE	Institute for the Diversification and Saving of Energy
IDB	International Development Bank
IEA	International Energy Agency
IESR	Institute for Essential Services Reform
IMO	International Maritime Organization
IoT	Internet of Things
IRR	Internal Rate of Return
ITF	International Transport Forum
ITS	Intelligent Transportation Systems
JETP	Just Energy Transition Partnership
KPI	Key Performance Indicator
LAERFTE	The Law for the Development of Renewable Energy and Energy Transition Financing
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
LRT	Light Rail Transit
MaaS	Mobility-as-a-Service
MARPOL	The International Convention for Prevention of Marine Pollution For Ships
MIMS	Ministry of Sustainable Infrastructures and Mobility
MITMA	Ministry of Transport, Mobility, and Urban Agenda
MOVES	Spain’s national mobility plan
MRT	Mass rapid Transit
MTP	Medium Term Program
NDCs	Nationally Determined Contributions
NECP	The National Energy and Climate Plan (NECP)
NEV	New-Energy Vehicle
NGOs	Non-governmental organizations
NMVOC	Non-Methane Volatile Organic Compound
NOx	Nitric Oxide (NO), Nitrogen Dioxide (NO2)
NPM	National Platform Future of Mobility
NPV	Net Present Value
NS	Dutch Railways

OEMs	Original Equipment Manufacturers
OIZ	Organized Industrial Zones
ÖTV	Special Consumption Tax
PHEV	Plug-In Hybrid Electric Vehicle
PM	Particulate Matter
PM2.5	Particulate Matter 2.5
PRODESEN	Mexico's National Electric System Development Program
PtX	Power-to-X
R&D	Research and Development
SAF	Sustainable Aviation Fuel
SAS	Scandinavian Airlines System
SDGs	Sustainable Development Goals
SEMARNAT	The Secretariat of Environment and Natural Resources
SICT	The Secretariat of Infrastructure, Communications and Transportation
SMEs	Small and Medium-Sized Enterprises
SOx	Sulfur Oxide
SUVs	Sport Utility Vehicles
TEN-T	Trans-European Transport Network
TEUs	Twenty-Foot Equivalent Units
TUMI	Transformative Urban Mobility Initiative
UN	United Nations
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States Dollar
VAT	Value Added Tax
WRI	World Resources Institute
ZEV	Zero-Emission Vehicle
ZEV-EM-I	Zero Emission Vehicles Emerging Markets Initiative

Note: The country names used in this report are in line with the official designations provided by the Ministry of Foreign Affairs of the Republic of Türkiye. However, for the purposes of simplifying the text flow and enhancing readability, the countries concerned will be referred to in their shortened forms throughout the remainder of the report. Accordingly:

- The Federal Republic of Germany will be referred to as **Germany**;
- The People's Republic of China as **China**;
- The United Mexican States as **Mexico**;
- The Republic of Indonesia as **Indonesia**;

- The Republic of Chile as **Chile**;
- The Kingdom of Spain as **Spain**;
- The Kingdom of the Netherlands as **the Netherlands**;
- The Kingdom of Denmark as **Denmark**.

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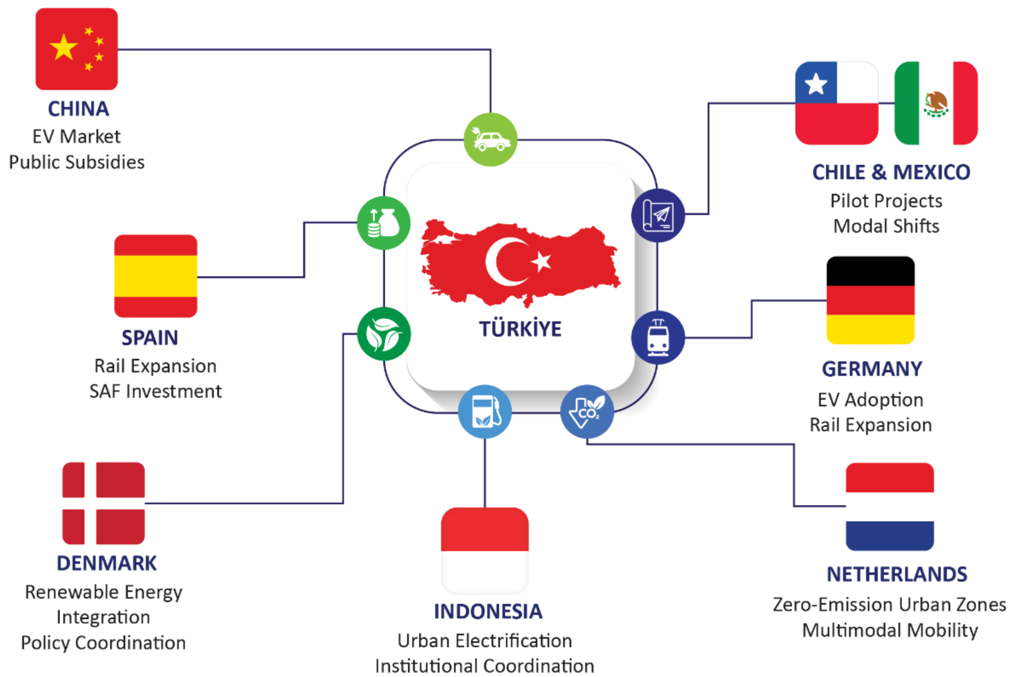
BENCHMARKING REPORT – TRANSPORT SECTOR DECARBONIZATION: STRATEGIC INSIGHTS FOR TÜRKİYE

8 Countries, 1 Goal: Türkiye's 2053 Net Zero Emission Target

Good practice examples related to the decarbonization of the transport sector have been examined.



MAIN ANALYSIS HEADINGS

- Policy Frameworks
- Emission Performance
- Renewable Integration
- Infrastructure and Technologies
- Socio-economic Dimensions
- International Cooperations

* ***This report benchmarks decarbonization strategies in eight countries offering critical guidance for Türkiye's 2053 Net Zero Transport Target.***

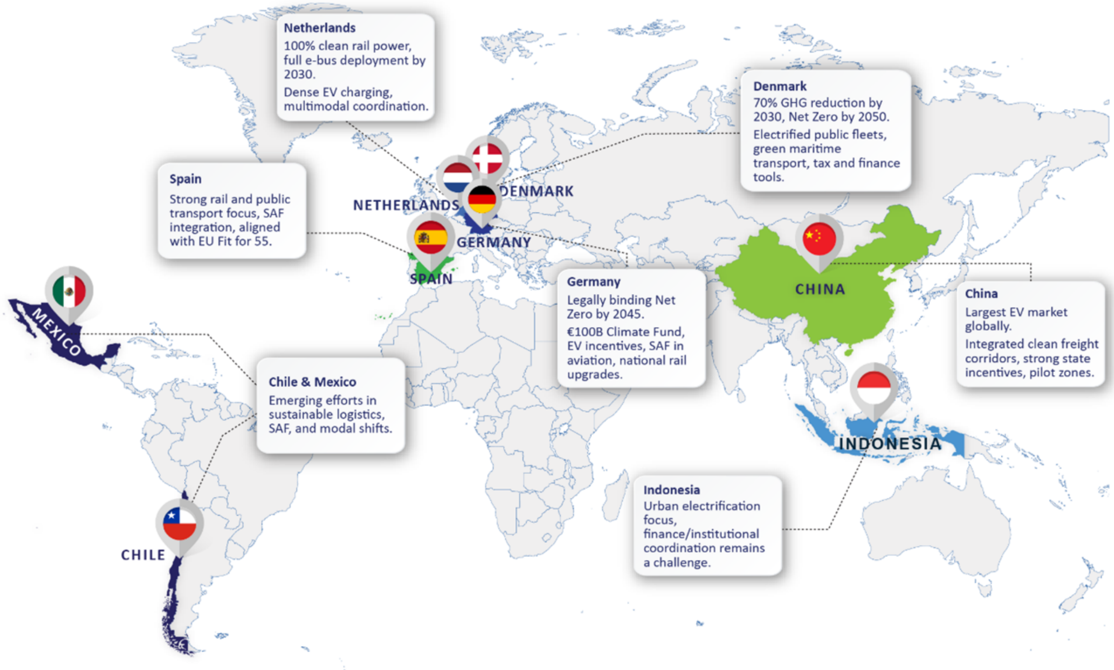
OBJECTIVE

To identify globally proven practices and structural strategies that can accelerate Türkiye's low-emission transport transformation, aligning national plans with global climate goals.

BENCHMARKING METHODOLOGY

- **9 evaluation criteria** were applied across selected countries.
- Scoring was based on a 1–10 scale, combining **qualitative** and **quantitative metrics**.
- Input was gathered from **experts in public, private, and academic sectors.**

Key Takeaways from Benchmark Countries



RELEVANCE FOR TÜRKİYE

Strengths:

- **Strategic logistics position** between Europe and Asia.
- **Growing renewables base** for electrification and hydrogen.
- **Industrial readiness** (Supply chains and Manufacturers of electric and hybrid light vehicles, buses, and trucks, with TOGG being a leading example).
- **Urban transport progress** (metro, electric buses).

Gaps:

- **No binding transport targets.**
- **Weak EV incentives**, especially for low-income groups.
- **Underused rail network.**
- **Lack of national transport data system.**

Strategic Recommendations:

1. **Net Zero Transport Pilot Zones** (cities/corridors with EVs, charging, green logistics).
2. **National Sustainable Mobility Law** aligning local-national decarbonization efforts.
3. **Leverage international climate finance** (Horizon Europe, CIF, etc.) for EVs, SAF, rail.
4. **Strengthen public-private innovation partnerships** (battery, e-fuels, mobility platforms).

Conclusion:

Türkiye's pathway to Net Zero by 2053 is ambitious yet achievable. With targeted legal, financial, and infrastructural reforms inspired by international best practices, Türkiye can lead the region in sustainable mobility.

2

EXECUTIVE SUMMARY

This benchmarking report evaluates transport sector decarbonization strategies in eight selected countries—Denmark, Germany, the Netherlands, and Spain from the EU; and China, Chile, Mexico, and Indonesia from developing economies—with the aim of guiding Türkiye's Net Zero Emission goals for the transport sector. The study provides comparative insights on policy frameworks, emissions performance, infrastructure and technology, renewable energy integration, socio-economic dimensions, innovation capacity, and international collaboration.

Context and Purpose

As Türkiye aspires to reach Net Zero emissions in the transport sector by 2053, it becomes critical to learn from countries that demonstrate leadership in low-emission mobility transitions. The report identifies exemplary practices and structural policies from benchmark countries to shape Türkiye's strategic objectives, action plans, and roadmaps. This executive summary highlights key findings and strategic lessons from the benchmarking analysis.

Benchmarking Framework and Methodology

Countries were evaluated based on eight criteria:

Figure 1: Benchmarking Criteria

Each country was scored on a 1–10 scale per criterion, combining expert input from public, private, and academic stakeholders. Both qualitative and quantitative indicators were used, enabling a multidimensional comparison.

Key Insights from Benchmark Countries

1. Denmark: Denmark is a global frontrunner with a 70% GHG reduction target by 2030 and full Net Zero by 2050. The country has successfully integrated renewable energy into transport, electrified public transport fleets, and deployed strategic infrastructure such as the Fehmarnbelt Tunnel and electric ferry networks. Strong policy coordination, tax incentives, and climate finance tools like green bonds support this transformation.

2. Germany: Germany has set legally binding targets for climate neutrality by 2045. Key strategies include scaling EV adoption (15 million by 2030), SAF blending for aviation, expansion of the rail network, and targeted subsidies (e.g., Deutschlandticket, EV purchase incentives). Germany's €100 billion Climate and Transformation Fund underpins its decarbonization across all transport modes.

3. Netherlands: The Netherlands aims for 55% GHG reduction by 2030 and Net Zero by 2050, with full electrification of buses by 2030 and 100% clean energy in rail transport already achieved. The country leads in zero-emission urban zones and offers high-density EV charging infrastructure. It pioneers multimodal sustainable mobility through strong local-national coordination.

4. Spain: Spain's targets include a 23% GHG reduction by 2030 and 90% by 2050. The country emphasizes rail expansion (e.g., high-speed AVE lines), SAF investment in aviation, and integrated public transport modernization. Spain's national energy and climate plan is aligned with Fit for 55 and EU ETS extensions.

5. China: As the largest EV market globally, China combines industrial scale with innovation. The country targets Net Zero by 2060 and has integrated clean energy into freight corridors and public fleets. Local pilot zones and massive public subsidies drive rapid scaling of zero-emission technologies.

6. Chile & Mexico: Both countries are at earlier stages but show promise. Chile aligns with international SAF goals and is developing pilot projects for maritime decarbonization. Mexico emphasizes modal shifts to rail and increased investment in sustainable logistics corridors.

7. Indonesia: Indonesia has a 2060 Net Zero target, focusing on urban transport electrification and modal shifts in dense corridors. Institutional coordination remains a key challenge, alongside finance for EV infrastructure.

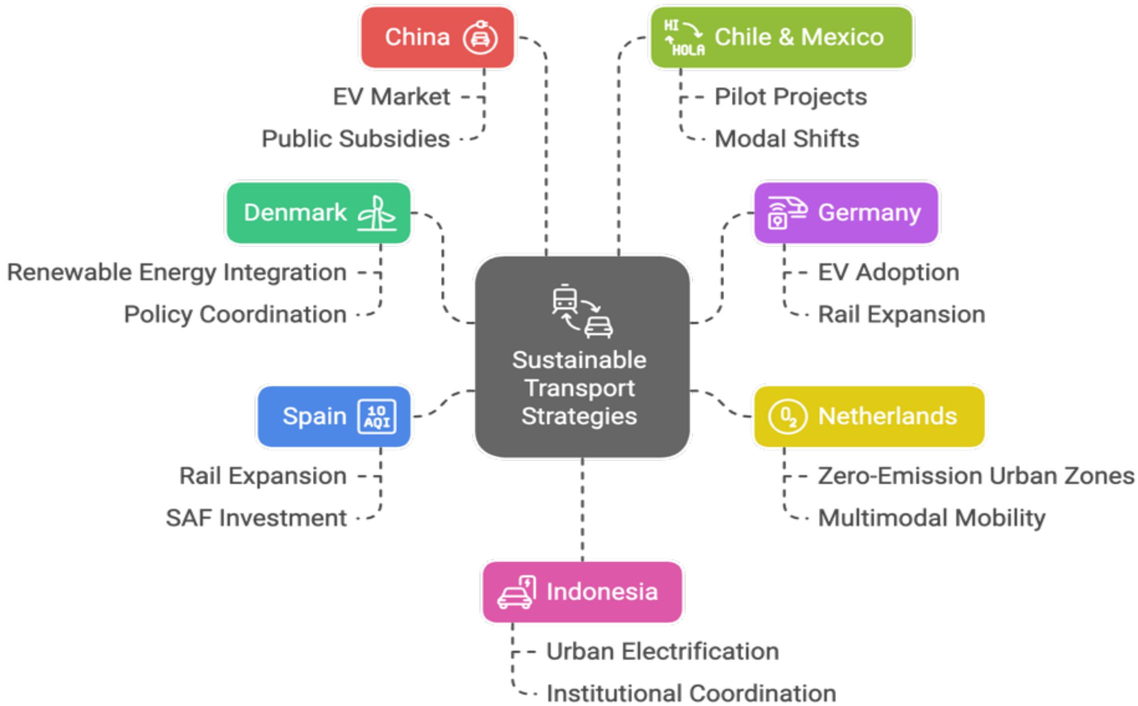


Figure 2: Benchmarking Countries

Applicability to Türkiye and Strategic Implications

Türkiye's 2053 Net Zero commitment presents both a challenge and an opportunity to transform its transport sector. Insights from benchmark countries highlight key strengths Türkiye can leverage, as well as areas needing further development.

Strengths and Opportunities

- **Strategic location and logistics potential**: Türkiye's position as a bridge between Europe and Asia provides a unique opportunity to develop green freight corridors and expand rail and maritime transport.
- **Expanding renewable energy base**: The growing share of solar and wind energy can support transport electrification and future hydrogen applications, aligning with practices in Denmark and the Netherlands.
- **Domestic e-mobility and industrial capacity**: Initiatives such as manufacturers of electric and hybrid light vehicles, buses, and trucks—most notably TOGG—together with a strong automotive supply chain, place Türkiye in an advantageous position to scale up electric vehicle production and battery technologies.

- **Urban transport progress**: Major cities have made strides in expanding metro lines and electric bus fleets, showing implementation capacity when supported by public investment.

Areas for Improvement

- **Lack of binding transport-specific targets**: Türkiye would benefit from legal frameworks that define specific emission reduction, renewable energy usage, energy efficiency etc. goals for sub-sectors, as seen in Germany and Denmark.
- **Insufficient incentives for EV adoption**: A more robust and long-term incentive system—fleet transition and charging infrastructure especially for low-income users and commercial fleets—is needed to boost EV market share.
- **Underutilized rail potential**: Despite high emissions from road transport, rail and intermodal systems remain underdeveloped. Türkiye could adopt models like Denmark's "One-Hour Strategy" to improve rail competitiveness.
- **Limited data-driven decision-making**: Establishing a national transport data platform could support performance tracking, accountability, and evidence-based policymaking.

Strategic Recommendations

- Establish **Net Zero Transport Pilot Zones** in selected cities or corridors combining EVs, charging infrastructure, and green logistics.
- Develop a **National Sustainable Mobility Law** to harmonize local and national transport decarbonization goals.
- Utilize **international climate financing instruments** (e.g., Horizon Europe, Climate Investment Funds) to support SAF development, EV charging, and rail upgrades.
- Strengthen **public-private partnerships** in battery manufacturing, e-fuel R&D, and smart mobility platforms.

This report underscores the urgency and feasibility of decarbonizing transport in Türkiye through an adaptive strategy rooted in global best practices, local conditions, and ambitious yet realistic pathways to 2053 Net Zero goals.

1 INTRODUCTION

This benchmarking report refers to the output for Activity 1.1.2 and evaluates transport sector decarbonization strategies in eight countries—Denmark, Germany, Netherlands, Spain (EU); and China, Chile, Mexico, and Indonesia from developing economies, with the aim of guiding Türkiye's Net Zero Emission goals for the transport sector. The study provides comparative insights on policy frameworks, emissions performance, infrastructure and technology, renewable energy integration, socio-economic dimensions, innovation capacity, and international collaboration.

1.1 Background

Eight countries that we foresee to be beneficial for Türkiye's Net Zero Emission Target: Road Map for Transport project have been determined through detailed examinations and the approval of ERA has been obtained. While choosing the countries for benchmarking, the studies of the countries on zero emissions, the progress they have made, their population structures, economic conditions and transportation systems were taken into account. Accordingly, it has been tried to select those who have the best practices from developed and developing countries that will set an example for Türkiye. Four of them were selected from EU countries and the other four from developing countries. The GHG Reduction Targets for these countries, which are compared in detail in terms of many criteria and examples of the best transportation practices, are summarized in Table 1.

Table 1. Comparing the Benchmarked Countries

Country	GHG Reduction Target by 2030	GHG Reduction Target by 2050	Net-Zero Target Year
Germany	65% below 1990 levels	*N/A (net-zero by 2045)*	2045
Denmark	70% below 1990 levels	100% (net-zero)	2050
Spain	23% below 1990 levels	90% below 1990 levels	2050
Netherlands	55-60% below 1990 levels	95% below 1990 levels	2050
Mexico	35% below business-as-usual (BAU)	50% below 2000 levels	2050
Chile	30% below 2016 levels	95% below 2016 levels	2050
Indonesia	31.89% below BAU	43.2% below BAU	2060 or sooner
China	Reduce CO_2 emissions intensity by over 65% from 2005 levels	*N/A (net-zero by 2060)*	2060

Characteristics of the benchmarked EU countries are presented Table 2 below:

Table 2. Characteristics of the Benchmarked EU Countries

	Germany	Denmark	Netherlands	Spain	Türkiye
GDP in 2023 (USD Trillions)[1]	4.45	0.40	1.12	1.58	1.11
Population in 2023 (Millions)	84.7	5.9	17.6	48.6	85.4
Population Density in 2023 (per km²)	237.2	138	424	96	108.9
Land Area (km²)	357,022	43,094	41,543	505,944	783,562
Total Number of Vehicles (Millions)[2]	53.50	3.21	10.49	30.24	28.70
% Clean Fuel Vehicles[3]	5.4%	11%	8.3%	1.5%	0.6%
Market Share of Clean Fuel Vehicles[4]	24%	46%	35%	12%	10%

Characteristics of the benchmarked developing countries are presented Table 3 below:

[1] World Bank. (2023, March 25). GDP in 2023. Retrieved from World Bank: https://data.worldbank.org/indicator/NY.GDP.MKTP.CD
[2] ACEA. (2024). Vehicles on European Roads. ACEA. Retrieved from https://www.acea.auto/files/ACEA-Report-Vehicles-on-European-roads-.pdf
[3] TURKSTAT. (2025, March 25). Road Motor Vehicles, December 2023. Retrieved from Turkish Statistical Institute: https://data.tuik.gov.tr/Bulten/Index?p=Road-Motor-Vehicles-December-2023-49432&dil=2
[4] International Energy Agency. (2025, March 25). Global EV Data Explorer. Retrieved from IEA: https://www.iea.org/data-and-statistics/data-tools/global-ev-data-explorer

Table 3. Characteristics of the Benchmarked Developing Countries

	China	Chile	Mexico	Indonesia	Türkiye
GDP in 2023 (USD)[5]	17.79 trillions[6]	335.5 billions	1.79 trillions	1.37 trillions	1.11 trillions
Population in 2023 (Millions)	1,422.6	19.6	277.5	128.5	85.4
Population Density in 2023 (per km²)	148	25	67	143	109.5
Land Area (km²) (thousand)	9.597	756	1,973	1,905	783
Total Number of Vehicles (Millions) in 2023[7]	318.03	4.75	45.08	21.11	28,7[8]
% Clean Fuel Vehicles[9]	35,7 %[10]	0.1 %	0.1 %	-	0.6 %
Market Share of Clean Fuel Vehicles[11]	38 %[12]	0.3 %	1.3 %	-	10 %

[5] World Bank. (2023, March 25). GDP in 2023. Retrieved from World Bank: https://data.worldbank.org/indicator/NY.GDP.MKTP.CD
[6] Myllyvirta, L. (2025, March 25). Analysis: Clean energy was top driver of China's economic growth in 2023. Retrieved from Carbon Brief: https://www.carbonbrief.org/analysis-clean-energy-was-top-driver-of-chinas-economic-growth-in-2023/
[7] Circular Economy Indicators Coalition. (2025, March 25). Chile Registered Motor Vehicles. Retrieved from CEIC: https://www.ceicdata.com/en/indicator/chile/motor-vehicle-registered
[8] TURKSTAT. (2025, March 25). Road Motor Vehicles, December 2023. Retrieved from Turkish Statistical Institute: https://data.tuik.gov.tr/Bulten/Index?p=Road-Motor-Vehicles-December-2023-49432&dil=2
[9] The percentage represents the proportion of new energy vehicles, including battery electric vehicles, plug-in hybrid electric vehicles, and range-extended electric vehicles, relative to the total passenger vehicle market in China for the year 2023. This figure highlights the substantial adoption of clean fuel technologies in the Chinese automotive market.
[10] Tu, A. C. (2025, March 25). Fuel for Thought: Electrification in China — On Track but Challenging. Retrieved from S&P Global: https://www.spglobal.com/mobility/en/research-analysis/fuel-for-thought-electric-vehicle-adoption-trends-china.html
[11] International Energy Agency. (2025, March 25). Global EV Data Explorer. Retrieved from IEA: https://www.iea.org/data-and-statistics/data-tools/global-ev-data-explorer
[12] Myllyvirta, L. (2025, March 25). Analysis: Clean energy was top driver of China's economic growth in 2023. Retrieved from Carbon Brief: https://www.carbonbrief.org/analysis-clean-energy-was-top-driver-of-chinas-economic-growth-in-2023/

1.2 Objectives

The aim of this benchmarking study is to examine the "Net Zero Emission in Transport" studies of EU countries and developing countries that can set a reference for Türkiye.

As a result of the evaluations, Denmark, Germany, the Netherlands and Spain from Europe; and China, Chile, Mexico and Indonesia from developing countries, were selected as benchmark countries.

These countries were evaluated in terms of macroeconomic indicators and net zero emissions. Best practices in these countries have been identified. The points of the transportation sector in Türkiye that are open to development were also evaluated.

Then, inspired by the best practices in benchmarking countries, possible contributions will be made to guide Türkiye's net zero emission in transport sector.

The main purpose of this benchmarking report is to ensure that proven practices in the world are taken into account in order to determine the strategies, actions and pathways to be put forward in the later stages of the project in a more applicable and accurate way.

2 METHODOLOGY

2.1 Benchmarking criteria

As a result of the literature and country-based applications research, many criteria were found to compare the applications. Among these criteria, the ones that are suitable for Türkiye have been determined as follows by the evaluation of the experts. In the next section, data and information on these criteria are collected and summarized for each of the selected EU and developing countries.

A. **Policy and Regulatory Framework**
    a. National Targets and Strategies
    b. Regulatory Measures
    c. Incentives
B. **Emissions Performance**
    a. Transport Sector Emissions
    b. Emission Intensity
    c. Progress in Reducing Emissions
C. **Infrastructure and Technology**
    a. Electrification
    b. Public Transport and Modal Shifts
    c. Railway Decarbonization
    d. Maritime and Aviation
D. **Renewable Energy Integration**
    a. Fuel Mix
    b. Grid Decarbonization
    c. Investment in Renewable Projects
E. **Economic and Social Factors**
    a. Affordability and Accessibility
    b. Job Creation
    c. Equity and Inclusion
F. **International Collaboration and Financing**
    a. Participation in Global Initiative
    b. Climate Finance
G. **Innovation and R&D**
    a. Development of New Technologies
    b. Patents and Innovation
    c. Pilot Projects

H. Performance of Key Transport Modes

a. Road Transport
b. Public Transport
c. Railways
d. Aviation
e. Maritime

2.2 Analysis framework

The analysis framework determined for this benchmarking study consists of the following basic steps.

- First of all, the purpose and scope of the study are clarified. In this context, the targets we expect from the study and which countries will be taken into account have been determined.
- The criteria and sub-criteria to be used in the study were selected. It has been investigated from which sources data can be obtained regarding these criteria.
- Data collection and analysis is the most important aspect of the study. Qualitative and quantitative data were collected from the countries to be compared on the criteria determined by internet-based and desk-based work.
- In order to obtain useful results, the situation in Türkiye was presented against the best practices in the selected countries and the gap analysis was made. Suggestions have been made on which best practices can be adapted to Türkiye and in what way.
- Each country is assessed across multiple key performance indicators (KPIs) from policy ambition to on-the-ground outcomes.
- Each KPI category is scored on a 1–10 scale (10 = leading performance) based on current progress and 2024–2050 plans.
- Countries are compared based on their strengths and weaknesses in: A) Policy Framework; B) Emissions Performance; C) Infrastructure & Technology; D) Renewable Energy Integration; E) Economic & Social Factors; F) International Collaboration; G) Innovation & R&D; and H) Decarbonization of Key Modes. At the end, an overall ranking and summary table prepared by highlighting which countries are front runners and which are lagging.
- The evaluation of the countries in terms of criteria was carried out by a large team of experts. The team of experts was selected from the public, private sector, NGOs and academia. Each of them is an expert in certain modes of transport or in the field of public transport, and they have looked at it from their own window while making their assessments. When all scores were combined, generalized results were obtained for each criterion.

3 SELECTED EU COUNTRIES FOR BENCHMARKING

3.1 Denmark

Net Zero Target: 70% emission reduction by 2030, Net Zero by 2050.

Denmark has been a frontrunner in climate policies, aiming for a 70% reduction in greenhouse gas emissions by 2030 and Net Zero emissions by 2050. Their initiatives include the following: Electrification of Transport, Green Tax Reforms, Renewable Energy Integration, Public Transport and Non-Motorized Travel, Carbon Capture and Storage and International Collaboration, collaborating with Nordic and European partners to advance decarbonization efforts. Denmark's Climate Act mandates annual climate programs to ensure progress towards these targets.

The GHG emissions have consistently decreased in Denmark since 1996. The main reason for this outstanding decline is related to the use of renewable energy in electricity generation and district heating as well as consistent political will and the result of solid cooperation between public and private actors. Denmark has set out on an ambitious journey to achieve Net Zero emissions, guided by a robust legal and strategic framework. The Climate Act has been updated to target a 70% reduction in emissions by 2030 (%40 reduction has already achieved) and Net Zero by 2045, with plans to exceed these targets by 2050.

These are the transport initiatives carried out in Denmark:

- Rising Emissions Challenge - Tackling emissions from road, aviation, and marine transport.
- Electric Vehicle (EV) Promotion - Ministry of Transport encourages EV adoption through tax incentives.
- Renewable Integration - Ministry for Climate, Energy, and Utilities incorporates renewable energy into transport.
- Financial Support - Ministry of Finance and private partners use the Danish Green Investment Fund and sovereign green bonds to fund sustainable transport, backed by the EU Emissions Trading Scheme and carbon taxation.

The Table 4 below summarizes the target details for different transport modes:

Table 4. Target Details for Different Transport Modes in Denmark

DENMARK [13] [14] [15]	
Transport modes	**Target Details**
Road Transport[16]	2030 Goals: Reduce emissions from road transport by 70% compared to 1990. Ban on sales of new fossil fuel cars by 2030, with a goal for at least 1 million electric vehicles.
	2050 Goal: Achieve a fully electric vehicle fleet and increase bike and pedestrian infrastructure for urban transport.
Public Transport[17]	2030 Goals: Transition to zero-emission buses in cities by 2025 and in regional transport by 2030.
	2050 Goal: Fully electrify public transport systems, supported by renewable energy sources, and phase out fossil fuels entirely.
Rail Transport[18]	2030 Goals: Increase electrification of the rail network with ambitions to fully electrify by 2030, particularly for passenger lines.
	2050 Goal: Complete decarbonization of the rail network, with a focus on renewable energy.
Aviation[19]	2030 Goals: Increase the share of sustainable aviation fuel (SAF) for domestic flights, aiming for carbon-neutral domestic flights by 2030.
	2050 Goal: Net-zero in all aviation sectors through extensive SAF usage and carbon offsetting.
Maritime[20]	2030 Goals: Expand the use of green fuels (e.g., methanol, ammonia) and shore-side power at ports to cut emissions.
	2050 Goal: Full decarbonization of maritime transport, with electric ferries for shorter routes and alternative fuels for longer routes.

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13 European Hydrogen Observatory. (2025, June 20). Sustainable and Smart Mobility Strategy. Retrieved September 3, 2025, from European Hydrogen Observatory: https://observatory.clean-hydrogen.europa.eu/eu-policy/sustainable-and-smart-mobility-strategy

14 European Comission. (2021, July 21). Mobility Strategy. Retrieved September 3, 2025, from European Comission: https://transport.ec.europa.eu/transport-themes/mobility-strategy_en

15 State of Green. (2025, February 28). Denmark on track to meet climate targets. Retrieved September 3, 2025, from State of Green: https://stateofgreen.com/en/news/denmark-on-track-to-meet-climate-targets/

16 Ea Energy Analyses. (2015). Green Roadmap 2030. Ea Energy Analyses. Retrieved September 3, 2025

17 European Commission. (2024, December 18). Denmark: Movia Reaches Electric Bus Target Six Years Early. Retrieved March 25, 2025, from European Alternative Fuels Observatory: https://alternative-fuels-observatory.ec.europa.eu/general-information/news/denmark-movia-reaches-electric-bus-target-six-years-early

18 Arctic Today. (2024, July 1). The Danish State Railways and European Energy sign agreement for new solar park construction. Retrieved September 1, 2025, from Arctic Today: https://www.arctictoday.com/%F0%9F%87%A9%F0%9F%87%B0-the-danish-state-railways-and-european-energy-sign-agreement-for-new-solar-park-construction/

19 BBC. (2022, January 2). Denmark to make domestic flights fossil fuel free by 2030. Retrieved September 3, 2025, from BBC: https://www.bbc.com/news/world-europe-59849898

20 The Danish Goverment's Climate Partnership. (n.d.). Blue Denmark. Retrieved September 3, 2025, from The Danish Goverment's Climate Partnership: https://climatepartnerships2030.com/the-climate-partnerships/blue-denmark

Within the scope of examining the countries according to the benchmarking criteria, the information and documents of the following institutions were taken into consideration:

- Ministry for Climate, Energy and Utilities,
- The Ministry of Ecological Transition,
- The Ministry of Sustainable Infrastructures and Mobility (MIMS).

Benchmark Criteria for Denmark

1. Policy and Regulatory Framework

1.1. National Targets and Strategies

- Denmark's national target for 2030 under the Danish Climate Act: 70% reduction in total GHG net emissions from 1990 levels (Samuelsen, 2024).
- Long-term target: Climate neutrality by 2050 or 2045, with the government aiming for a 110% reduction by 2050 (net negative emissions) (Samuelsen, 2024).
- By 2030, at least 5% of the Danish-operated fleet will be capable of running on well-to-wake net zero-emission fuels such as green hydrogen, green ammonia, green methanol, and advanced biofuels (Danish Shipping, 2022).
- All new buildings ordered by Danish ship-owners from 2030 are to be made ready for net zero-emission fuels or other zero-emission means of propulsion (Danish Shipping, 2022).

1.2. Regulatory Measures

- Fundamental restructuring of vehicle taxation to encourage the purchase of energy-efficient cars (International Energy Agency, 2017).
- Implementation of road pricing policy to make driving in urban areas during rush hour more expensive, thus increasing demand for public transport (International Energy Agency, 2017).
- Executive Order on Chargers: Buildings with more than 20 parking slots must have at least 1 charging station. New constructions with more than 10 parking spaces must establish at least 1 charging station (European Commission, 2025).
- Green car tax shift to incentivize low-emission vehicles (The Danish Government, 2008).

1.3. Incentives

- Tax exemption for electric vehicles (EVs) until 2012, with subsequent tax reductions until 2015 (International Energy Agency, 2017).

- 60% discount on the registration tax for EVs in 2021, gradually decreasing to 20% until 2030 (European Commission, 2025).
- Battery taxation deduction of DKK 1,700 (European Commission, 2025).
- Discount of DKK 0.12 per kWh when charging an EV or PHEV (European Commission, 2025).
- Free charging of battery electric vehicles (BEVs) at work (European Commission, 2025).
- Subsidy for charge point installation at housing associations (European Commission, 2025).
- Government provision of DKK 50 million for public charging stations (European Commission, 2025).
- Tax exemption for commercial charging, effective through 2024 (European Commission, 2025).
- Favorable tariffs for electric buses, extended to 2024 (European Commission, 2025).
- From January 1, 2024, electricity tax reimbursement rate of 94.63 øre/kWh including VAT for EV charging (European Commission, 2025).
- The country has designated DKK 1.5 million in 2023 for the development of road pricing trials for passenger cars (Kadiri, Denmark's EV Revolution: Tax Benefits and Infrastructure Boost, 2025).

2. Emissions Performance

2.1. Transport Sector Emissions

- The transport sector is a significant contributor to Denmark's greenhouse gas emissions:
- In 2022, the transport sector accounted for 26% of Denmark's total net GHG emissions, making it the largest emitting sector alongside agriculture (European Union, 2023).
- As of 2022, transport accounted for 38% of total emissions under the EU Effort Sharing Regulation (ESR) in Denmark (European Union, 2023).
- Road freight transport alone emits around 3 million tons of CO_2 per year, which equals 25% of the transport sector's emissions, or 6% of Denmark's total national greenhouse gas emissions (Gudmundsson, 2020).
- The Danish transport sector contributed approximately 20% of the total Danish carbon dioxide emissions from energy-consuming sectors (Haq, Bush, & O'Reilly, 2012).

2.2. Emission Intensity

- From 1990 to 2018, fuel consumption and CO_2 emissions for road transport increased by 38% and 32%, respectively (Winther, 2020).

- Heavy trucks and semitrailers (26t total weight and upwards) make up 60% of the truck fleet but account for over 85% of CO_2 emissions from road freight transport (Gudmundsson, 2020).
- In 2022, the transport sector was the largest energy consumer in Denmark, accounting for 31% of total final energy consumption (International Energy Agency, n.d.).

2.3. Progress in Reducing Emissions

Denmark has made some progress in reducing transport emissions, but significant challenges remain:

- Emissions from the transport sector are expected to decrease by almost 35% by 2035 compared to 2019 levels (UNFCCC secretariat, 2024).
- According to the latest draft projection (April 2024), CO_2 emissions in the transport sector are estimated to be reduced by 7.5 million tonnes or about 60% from 2019 to 2035 (UNFCCC secretariat, 2024).
- The share of renewable energy in the transport sector is projected to reach approximately 35% by 2035, primarily due to the expected rise in electric vehicles and phase-out of fossil-fueled cars (UNFCCC secretariat, 2024).
- From 1990 to 2018, there were significant reductions in certain pollutants from road transport: CH4 emissions decreased by 88%, and emissions of NOx, NMVOC, CO, particulates (exhaust only, below PM2.5), and BC decreased by 68%, 90%, 89%, and 19% respectively (Winther, 2020).
- Denmark is on track to achieve its 70% emissions reduction target by 2030, according to recent reports (Hunter, 2024).

Despite these improvements, the transport sector remains a significant source of emissions, and further efforts are needed to meet Denmark's climate goals (UNFCCC secretariat, 2024).

3. Infrastructure and Technology

3.1. Electrification

Denmark has made significant progress in electrifying its transport sector, particularly in public transportation:

- As of February 2025, Movia, Denmark's largest public transport operator, has electrified 50% of its bus fleet in the Copenhagen capital region and Zealand, six years ahead of the original 2030 target.
- Movia now operates 565 purely electric buses out of a total fleet of 1,126 buses.

- These electric buses cover over 51 million kilometers annually, significantly reducing environmental impacts.
- The 66 new electric buses added recently are expected to cut annual CO_2 emissions by 3,100 tonnes on a tank-to-wheel basis (European Commission, 2024).
- Between 2023 and 2025, the government has earmarked DKK 92.5 million to co-finance charging stations in housing associations, while also requiring that all new buildings and parking facilities be equipped to support EV charging infrastructure (Kadiri, Denmark's EV Revolution: Tax Benefits and Infrastructure Boost, 2025).

3.2. Public Transport and Modal Shifts

Denmark is actively promoting public transport and encouraging modal shifts:

- Copenhagen and Frederiksberg municipalities have agreed to electrify all bus operations by the end of 2025.
- As of February 2023, thirteen bus lines in Copenhagen were emission-free, with plans to increase this to 22 lines by the end of that year.
- The six largest Danish municipalities, including Copenhagen, committed in June 2021 to purchase only zero-emission buses from 2021 onwards (Sustainable Bus, 2023).

3.3. Railway Decarbonization

Denmark's railway system is undergoing significant modernization to enhance sustainability, efficiency, and international connectivity. Banedanmark is leading an extensive electrification programme, aiming to convert up to 1,300 km of mainline tracks from diesel to electric by 2029, with several key sections already completed. To further reduce emissions, the country is preparing infrastructure to accommodate battery-powered trains, including upgrades on the Skjern–Holstebro line. However, the nationwide rollout of the European Rail Traffic Management System (ERTMS) has faced delays, pushing the full deployment deadline to 2033 due to technical and logistical challenges. A landmark project, the 18 km Fehmarnbelt Tunnel connecting Denmark and Germany, is under construction and expected to open in 2029, significantly reducing travel time between Copenhagen and Hamburg. Urban rail developments include the transition of Copenhagen's S-train network to a fully automated system and the anticipated launch of the Greater Copenhagen Light Rail in 2025. Despite these advancements, passengers, particularly in eastern Denmark, may experience service disruptions due to ongoing infrastructure upgrades and signalling system transitions.

The "One-Hour Model" (Timemodellen) in Denmark's railway system is a strategic infrastructure plan aimed at significantly reducing travel times between major Danish cities, with the goal of enabling train journeys of approximately one hour between key hubs.

This model aims to provide faster connections for passengers, making the railway system more competitive and helping to reduce CO_2 emissions, aligned with Denmark's climate goals by promoting rail over car and air travel (Haq, Bush, & O'Reilly, 2012).

3.4. Maritime and Aviation

Denmark is focusing on developing infrastructure for maritime transport and exploring low-emission solutions for aviation:

- Significant investments are being made to improve infrastructure in and around Danish seaports to promote maritime freight as a competitive and environmentally friendly alternative to land-based transport (Haq, Bush, & O'Reilly, 2012; Haq, Bush, & O'Reilly, 2012).
- The North Sea region, including Denmark, is becoming a hub for shipping, aviation, and industrial clusters, with a focus on developing low-emission hydrogen, e-fuels, and carbon capture utilization and storage (CCUS) technologies (International Energy Agency, 2023).

Denmark is also actively advancing the decarbonization of its aviation infrastructure, focusing on sustainable aviation fuels (SAF), green hydrogen technologies, and airport carbon neutrality:

- Denmark has allocated 3 billion DKK to boost SAF production and an additional 1.8 billion DKK to stimulate demand. A key initiative is the Fjord PtX project, a collaboration between SAS, Copenhagen Infrastructure Partners, and major airports, aiming to produce synthetic SAF using green hydrogen and captured CO_2 ((Schultz & Melchiorsen, n.d.).
- Copenhagen Airport is targeting net-zero emissions from its operations by 2030, aiming for a 90% reduction from 2019 levels and offsetting the remainder through carbon removal credits. The airport has achieved Level 4+ Transition in the Airport Carbon Accreditation scheme and is working towards Level 5 (Copenhagen Airport, n.d.).
- Scandinavian Airlines (SAS) plans to introduce electric aircraft for regional flights by 2028, utilizing the 30-seat ES-30 model developed with Heart Aerospace. This initiative aligns with Denmark's broader goals for sustainable aviation (Chang, 2023).

4. Renewable Energy Integration

4.1. Fuel Mix

Denmark is actively working to increase the share of renewable energy in its transport sector:

- The share of renewable energy in the transport sector is projected to reach approximately 35% by 2035, primarily due to the expected rise in electric vehicles and phase-out of fossil-fueled cars (UNFCCC secretariat, 2024).
- Denmark is exploring the use of biogas in heavy transport as part of its strategy to reduce emissions (Ea Energy Analyses, 2016).
- The country is also promoting the use of advanced biofuels, with recommendations to implement EU requirements for increased blending of advanced biofuels after 2020 (Ea Energy Analyses, 2016).
- Denmark is advancing Power-to-X (PtX) projects, including Fjord PtX, to produce synthetic Sustainable Aviation Fuel (eSAF) (AvionTourism, 2025). PtX refers to a range of technologies that transform electricity—primarily from renewable sources such as wind and solar—into alternative energy carriers or products. These can include hydrogen (Power-to-Hydrogen), synthetic fuels like e-methanol and eSAF (electrofuels), methane (Power-to-Methane), ammonia, various chemicals, or even heat.

These initiatives demonstrate Denmark's commitment to transitioning towards a more sustainable and environmentally friendly transport sector, with a strong focus on electrification, public transport improvements, and the integration of renewable energy sources.

5. Economic and Social Factors

5.1. Affordability and Accessibility

Denmark has made significant efforts to ensure affordability and accessibility in its transport system:

- By 2030, Denmark aims to provide access to safe, affordable, accessible, and sustainable transport systems for all, with special attention to vulnerable groups (Statistics Denmark, 2023).
- The country has implemented a five-level accessibility grading system for public transport, ranging from very high (more than 10 departures per hour with access to both buses and trains/metro) to no service (Statistics Denmark, 2023).
- As of December 2019, a significant portion of the Danish population had access to public transport within 500 meters of their dwellings (Statistics Denmark, 2023).

- Affordable tickets and fares are being implemented to reduce economic barriers to accessing transport (European Commission, 2022).
- Between 2023 and 2026, Denmark grants a tax exemption on employer-covered electricity costs for workplace EV charging, incentivizing companies to offer tax-free charging facilities for employees’ private electric vehicles. (Kadiri, Denmark’s EV Revolution: Tax Benefits and Infrastructure Boost, 2025).

5.2. Job Creation

- Denmark's focus on green transport and infrastructure development likely contributes to job creation in related industries.

5.3. Equity and Inclusion

Denmark is working towards an inclusive transport system:

- There's a focus on catering to the needs of those in vulnerable situations, including women, children, persons with disabilities, and older persons (Statistics Denmark, 2023) (European Commission, 2022).
- Efforts are being made to improve physical accessibility, including ramps, lifts, low-floor access vehicles, clear signage, and accessible information systems (European Commission, 2022).
- The country is addressing cultural and social factors that influence transport preferences and perceptions (European Commission, 2022).

6. International Collaboration and Financing

6.1. Participation in Global Initiatives

- Denmark is actively participating in global initiatives, particularly within the European Union framework, to address climate change and promote sustainable transport.

6.2. Climate Finance

- Denmark supports its transport decarbonization goals through ambitious climate finance initiatives that blend public investment and green finance tools. In 2021, the government signed agreements totaling DKK 265 million to subsidize publicly accessible EV charging infrastructure, DKK 72 million for heavy-duty vehicles’ low-emission refueling, DKK 50 million to promote zero- and low-emission heavy-duty vehicle fleets, and DKK 233 million for greening ferry services (International Energy Agency, 2022).

- Denmark provides substantial tax incentives for clean vehicles, with battery electric vehicles (BEVs) eligible for a 60% reduction in registration tax and plug-in hybrids (PHEVs) receiving a 35–50% discount. (European Commission, 2025).
- Denmark is promoting cooperation among major stakeholders—including SAS, Copenhagen Infrastructure Partners, and leading airports—to advance the transition toward sustainable aviation (AvionTourism, 2025).

7. Innovation and R&D

7.1. Development of New Technologies

Denmark is investing in new technologies to improve its transport system:

- The country is exploring the use of biogas in heavy transport as part of its strategy to reduce emissions.
- There's a focus on developing low-emission hydrogen, e-fuels, and carbon capture utilization and storage (CCUS) technologies, particularly in the North Sea region.
- Denmark has set up a charging infrastructure knowledge center, supported by a DKK 6 million allocation for the 2023–2025 period (Kadiri, Denmark's EV Revolution: Tax Benefits and Infrastructure Boost, 2025).

7.2. Patents and Innovation

- Denmark is a leader in zero-emission transport innovation, with Danish companies filing the highest number of green patents per capita among 25 Western nations—93 patents per million inhabitants in 2021 (Ministry of Foreign Affairs of Denmark, 2023). Nearly 19% of all Danish patent applications target climate change mitigation technologies, exceeding the European average (State of Green, 2023). Innovation efforts are particularly strong in areas such as wind energy, Power-to-X (PtX), and sustainable maritime fuels, including the world's first commercial-scale e-methanol facility supplying Maersk's green vessels (Reuters, 2024).

7.3. Pilot Projects

- While specific pilot projects are not mentioned in the search results, Denmark's commitment to sustainable transport likely involves various pilot initiatives, particularly in electrification and renewable energy integration.

8. Performance of Key Transport Modes

8.1. Road Transport

- In 2023, more than half of all journeys in Denmark were completed by passenger car.
- For journeys under 10 kilometers, car use drops to just under a third of trips (Statista, 2023).

8.2. Public Transport

- Public transport accounted for 16% of total transport mileage in Denmark in 2010 (Hansen & Rich, 2016).
- Copenhagen's public transport system is highly efficient, with 60% of metropolitan residents and jobs reachable within half an hour from the two most important rail hubs (Scheurer, 2013).
- The Danish government has committed to converting its entire public fleet to EVs by 2025 (Naeem, 2023).

8.3. Railways

- Denmark’s railway network had a total length of 2,610 km in 2024 (Statistics Denmark, n.d.).
- Rail passengers across the Great Belt corridor increased from 4.4 million before 1998 to 8.6 million in 2014 (Hansen & Rich, 2016).
- Denmark is implementing the "One-Hour Model" to improve connections between major cities, making the railway system more competitive.

8.4. Aviation

- Aviation accounted for 1% of total transport mileage in Denmark in 2010 (Hansen & Rich, 2016).
- Denmark targets its first fully sustainable domestic flight route by 2025 and plans to eliminate fossil fuels from all domestic flights by 2030, backed by a government allocation of DKK 1.8 billion to boost demand for sustainable aviation fuels (Ministry of Foreign Affairs of Denmark, 2025).

8.5. Maritime

- Denmark is investing in improving infrastructure in and around Danish seaports to promote maritime freight as a competitive and environmentally friendly alternative to land-based transport.

- Three of the largest, most-advanced port-infrastructure projects now under way in Denmark, all explicitly designed to boost maritime freight's competitiveness and green credentials:
    - Port of Esbjerg Expansion (Dual-Use Offshore & Military Terminal): Under the "ESBJERG PORT EXPANSION" scheme, the port is deepening its navigation channel and building a new 57 ha terminal to handle ever-larger offshore-wind components (blades >100 m) and fully laden military vessels. Funding comes from a mix of EU Connecting Europe Facility grants, Danish state support and a €115 million loan from the European Investment Bank (Koh, 2024).
    - Aarhus Port Onshore Power Facility: To eliminate "cold-ironing" emissions, Aarhus Port won an €18.8 million CEF grant to install shore-side electrical hookups for container vessels alongside its existing quays. When operational, ships can shut down diesel generators at berth, reducing CO_2, NO_x and particulate emissions by up to 90 % during loading/unloading Windows (Port News on Information Wave, 2025).
    - Container-Terminal & Quay Expansion at Aarhus (APM vs. MSC): APM Terminals has committed DKK 2 billion (≈USD 300 million) to build a second deep-water quay and yard extension, while MSC/TIL are concurrently developing a new 430 m quay at 14 m draft (Pakulniewicz, 2024).

3.2 Germany

Net Zero Target: 65% emissions reduction by 2030, Net Zero by 2045.

Germany, the largest emitter of GHGs in Europe, aims for Net Zero emissions by 2045. The Climate Protection Act sets legally binding targets and a framework for monitoring progress. Despite divergent views among coalition members, the government is accelerating climate policy implementation. The Climate Action Plan 2050, developed through federal ministry collaboration, targets a greenhouse gas-neutral economy by 2050, with specific measures for energy, transport, buildings, and agriculture.

The transport initiatives carried out in Germany are the following: Electrification of Vehicles - The government aims for 7-10 million EVs by 2030, supported by the "Umwelt bonus" (environmental bonus) and tax incentives, Charging Infrastructure - Plans to establish one million charging points by 2030, including rapid charging stations for long-distance travel, Rail Transport Expansion - Increasing rail freight transport to 25% by 2030 and enhancing the rail network for passenger travel, Alternative Fuels - Promoting the use of hydrogen, synthetic methane, and liquid synthetic fuels, Cycling and Car-Sharing - Expanding bike paths and supporting car-sharing services to reduce reliance on personal vehicles, Carbon Pricing - Implementing CO_2 pricing to incentivize emission reductions.

The Table 5 below summarizes the target details for different transport modes:

Table 5. Target Details for Different Transport Modes in Germany

GERMANY [21] [22]	
Transport Mode	**Target Details**
Road Transport[23]	**2030 Goals**: 40-42% GHG reduction from 1990 levels. Shift towards electric vehicles (15 million EVs by 2030), charging infrastructure development, and promotion of active transport (walking, cycling).
	2045 Goal: Nearly full electrification of light-duty vehicles and heavy-duty vehicles, with investments in hydrogen fuel cells and biofuels for areas where electrification may be less feasible.
Public Transport[24]	**2030 Goals**: Expansion of low-emission and zero-emission buses, aiming to phase out diesel buses in urban areas. Investments in high-speed rail and modernization of regional rail networks to decrease car reliance.
	2045 Goal: Achieve full decarbonization of public transport through electrification and green hydrogen for buses and trains.
Rail Transport[25]	**2030 Goals**: Electrification of 70% of rail lines (compared to around 60% currently), with some sections using hydrogen trains where electrification is challenging. Target for rail freight to carry 25% of all freight.
	2045 Goal: Full electrification and use of green energy sources, aiming for carbon-neutral rail transport across passenger and freight segments.

[21] European Comission. (2021, July 21). Mobility Strategy. Retrieved September 3, 2025, from European Comission: https://transport.ec.europa.eu/transport-themes/mobility-strategy_en
[22] Climate Change Laws. (2016, November). Climate Action Plan 2050. Retrieved September 3, 2025, from Climate Change Laws: https://climate-laws.org/documents/climate-action-plan-2050_b6ce?id=climate-action-plan-2050_37a5
[23] IRU. (2025, April 30). Germany backs pragmatic road transport decarbonisation. Retrieved September 3, 2025, from IRU: https://www.iru.org/news-resources/newsroom/germany-backs-pragmatic-road-transport-decarbonisation
[24] Meza, E. (2023, October 17). German govt agrees "green mobility update" in decarbonisation push for transport sector. Retrieved March 25, 2025, from Clean Energy Wire: https://www.cleanenergywire.org/news/german-govt-agrees-green-mobility-update-decarbonisation-push-transport-sector
[25] Kyllmann, C. (2024, November 18). Electrification of German railways falling behind. Retrieved September 3, 2025, from Clean Energy Wire: https://www.cleanenergywire.org/news/electrification-german-railways-falling-behind

GERMANY [21] [22]	
Aviation[26]	**2030 Goals**: Gradual increase in SAF use and research into synthetic fuels. Development of shorter-distance electric or hybrid-electric flights.
	2045 Goal: Transition to SAF for long-haul flights, with the goal of achieving net-zero aviation through fuel alternatives and carbon offsetting. Germany is also part of the EU's ReFuelEU initiative to scale up SAF production.
Maritime[27]	**2030 Goals**: Increase the use of LNG as a transitional fuel and expand shore-side electricity infrastructure for ports.
	2045 Goal: Adoption of green ammonia, green hydrogen, or battery technology for zero-emission maritime transport, focusing on ports and inland waterways.

Within the scope of examining the countries according to the benchmarking criteria, the information and documents of the following institutions were taken into consideration:

- The Ministry of Economic Affairs and Climate is responsible for developing and implementing policies, overseeing funding programmes, and ensuring coordination with federal states and the EU,
- The Ministry of Foreign Service carries out climate change negotiations in the international arena,
- The Ministry of Transport and Finance follows climate action within their scope of duty,
- The National Platform Future of Mobility (NPM), a think tank established to develop action recommendations for the government to achieve climate-neutral and future-oriented mobility- and CSOs actively participate in the policy making process.

Benchmark Criteria for Germany

1. Policy and Regulatory Framework

1.1. National Targets and Strategies

- Germany has legally committed to achieving net greenhouse gas neutrality by 2045, five years ahead of the 2050 global benchmark. The country has set interim targets, including

[26] IATA. (2025). German Aviation Policy. IATA. Retrieved September 3, 2025, from https://www.iata.org/contentassets/93bf461742084e8f9e0e378b9eb49483/brief-de-aviation-policy-en.pdf
[27] Federal Ministry for Economic Affairs and Energy. (2017). Maritime Agenda 2025. Retrieved September 3, 2025, from https://www.bundeswirtschaftsministerium.de/Redaktion/EN/Publikationen/maritime-agenda-2025.pdf?__blob=publicationFile&v=1

a 65% reduction in emissions by 2030 and an 88% reduction by 2040, relative to 1990 levels. These goals are enshrined in Germany's national climate law, which also outlines annual emission budgets for specific sectors such as industry and transport up to 2030 (Appunn, Eriksen, & Wettengel , 2025).

- Germany has set a goal of reaching 15 million electric vehicles by 2030; however, with only about 2.59 million EVs on the road in 2025, achieving this would require adding more than 12 million vehicles within five years—a pace demanding a significant acceleration in adoption.
- **Immediate program for compliance with climate targets in the transport sector**: Adaptation of national GHG reduction quota: increase of the existing GHG reduction quota to +1.0% in 2030 to strengthen the fulfillment options, e.g. via electricity-based fuels or advanced biofuels. In order to increase the incentives to use paraffinic fuels (such as renewable electricity-based diesel fuels or hydrogenated vegetable oils obtained from sustainable raw materials) as pure fuels, DIN EN 15940 is also to be included in the 10th BImSchV (Climate Change Laws, 2022).
- **Aviation:** Germany aligns with the European Union's aviation policies, which include participation in the EU Emissions Trading System (EU ETS) and adherence to the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). These frameworks aim to stabilize CO_2 emissions from international aviation at 2020 levels and promote the use of sustainable aviation fuels.
- **Maritime:** The German government has aligned with the International Maritime Organization’s (IMO) 2023 Greenhouse Gas Strategy, which updates the target to achieve net-zero greenhouse gas emissions from maritime activities by 2050.. National initiatives focus on promoting alternative fuels, such as liquefied natural gas (LNG) and hydrogen, and enhancing energy efficiency in maritime transport.
- **Road Transport:** Germany aims to reduce transport sector emissions by 40–42% by 2030 relative to 1990 levels. The government has set a target of having 15 million electric vehicles (EVs) on the road by 2030. However, current projections suggest that only about 8 million EVs will be registered by that time, indicating a need for additional measures to accelerate adoption.
- Starting in 2023, the country will introduce a CO_2-based infrastructure fee, exempting zero-emission vehicles until 2025, after which they will be subject to discounted rates (Transport & Environment, 2021).
- **Public Transport and Railways:** The government plans to double the volume of rail passenger transport by 2030 compared to current levels and increase the capacity and

attractiveness of public transport. Investments include €86 billion into the rail network by 2030, funded in part by increased freeway fees for trucks. The introduction of the "Germany ticket," a €49 monthly pass valid on all local public transit and regional trains nationwide, aims to boost public transport usage.

1.2. Regulatory Measures

- **Vehicles:** Germany adheres to the European Union's emission standards, known as the Euro standards, which regulate pollutants such as nitrogen oxides (NO_x), hydrocarbons (HC), carbon monoxide (CO), and particulate matter (PM). The current standard for new vehicles is Euro 6, which imposes stringent limits on these emissions. For heavy-duty vehicles, the Euro VI standard applies, setting rigorous emission limits to reduce environmental impact.
- **Vessels:** Germany complies with the International Maritime Organization's (IMO) MARPOL Annex VI regulations, which establish limits on NO_x and sulfur oxide (SO_x) emissions from ship exhausts. The IMO's Tier III standards, applicable in designated Emission Control Areas (ECAs), mandate significant reductions in NO_x emissions for ships built after January 1, 2016.
- **Aircraft:** Germany follows the International Civil Aviation Organization's (ICAO) standards for aircraft engine emissions, which set limits on NO_x, HC, CO, and smoke. The ICAO's Committee on Aviation Environmental Protection (CAEP) periodically updates these standards to incorporate advancements in technology and environmental considerations (International Policy, n.d.).
- **Biofuels:** Germany has established blending mandates requiring a certain percentage of biofuels to be mixed with conventional fuels. These mandates are part of the country's efforts to reduce greenhouse gas emissions in the transport sector.
- **Green Hydrogen:** Germany's National Hydrogen Strategy, adopted in 2020, emphasizes the production and use of green hydrogen, particularly in sectors that are challenging to decarbonize, such as heavy-duty transport and aviation. The strategy includes plans to develop hydrogen refueling infrastructure to support its adoption in transportation.
- **Electrification:** Germany has set ambitious targets to increase the number of electric vehicles (EVs) on the road, supported by incentives for EV purchases and investments in charging infrastructure. The government aims to have 15 million EVs by 2030 (International Energy Agency, 2023).

1.3. Incentives

- **Support scheme to rail transport operators**: To promote electrification and reduce carbon emissions in the transport sector, Germany is providing 1.1 billion EUR in compensation to rail transport companies that use electric drives. This support scheme will be delivered through a monthly reduction in electricity bills for rail transport operators, covering electricity consumption in 2023.
- Immediate program for compliance with climate targets in the transport sector: The programme is promoting electromobility in the area of cars and commercial vehicles. It is also promoting the expansion of the cycling infrastructure and of local public transport.
- Expansion of funding for efficient truck trailers: the funding program "Fleet Renewal Program for Heavy Commercial Vehicles" is to be designed as a component funding in the future, on the basis of which the purchase of additional CO_2-reducing equipment for new trailers and semi-trailers is to be subsidised (Climate Change Laws, 2023).
- Germany is actively involved in international collaborations to advance sustainable transport. The country participates in the Clean Energy Ministerial (CEM), a high-level global forum that promotes policies and programs to advance clean energy technology. The CEM encourages partnerships and collaboration between the private sector, public sector, and non-governmental organizations to fast-track the implementation of clean energy technologies, including those in the transport sector (The Organisation for Economic Co-operation and Development, n.d.).
- **Electric Vehicles (EVs):** Germany offers substantial subsidies for the purchase of electric vehicles. Buyers can receive up to €9,000 in incentives, combining federal and manufacturer contributions. Additionally, EV owners benefit from tax exemptions and reductions, including a 10-year exemption from the annual circulation tax. The government also supports the development of charging infrastructure through grants and low-interest loans.
- **Renewable Energy Integration:** Under the Renewable Energy Sources Act (EEG), Germany has established feed-in tariffs and market premiums to promote the generation of renewable energy, which indirectly supports low-carbon technologies in sectors like transportation (The Organisation for Economic Co-operation and Development, 2023).

2. Emissions Performance

2.1. Transport Sector Emissions

- As a highly industrialized nation with an extensive transportation network, Germany's transport sector is a notable source of its GHG emissions. The country has implemented various policies to reduce emissions, including promoting electric vehicles and enhancing public transportation infrastructure (World Bank Group, 2023).
- In 2021, the transport sector accounted for approximately 19% of Germany's total GHG emissions. Notably, emissions from this sector have been relatively stagnant, making it the slowest sector in terms of emission reductions (The Organisation for Economic Co-operation and Development, 2022).
- Germany is introducing revised landing procedures to lower CO2 emissions and adjusting flight routes to reduce contrail formation (Press Division, 2025).

2.2. Emission Intensity

- The transport sector in Germany has shown little progress in reducing emissions intensity over the past decades. Despite vehicles becoming less emission-intensive, increased road traffic and larger vehicles have offset these gains. In 2023, the transport sector was responsible for 21.6% of total emissions in Germany, with levels remaining largely unchanged from 1990 until the COVID-19 pandemic in 2020 (Appunn, Eriksen, & Wettengel , 2025).

2.3. Progress in Reducing Emissions

- In recent years, Germany has observed a decline in vehicle traffic, particularly in urban areas. Berlin, for instance, experienced a 12% reduction in traffic since 2019, with some suburban routes witnessing decreases up to 37% over the past decade. This trend is attributed to increased hybrid working models, rising fuel prices, and the introduction of the "Deutschlandticket," offering unlimited travel on many routes for €58 per month (Moody, 2024).

3. Infrastructure and Technology

3.1. Electrification

- Germany has been actively expanding its EV charging infrastructure to support the growing number of electric vehicles. As of February 2025, the country had approximately 161,628 public accessible charging points. In Berlin, there were 5,700 EV publicly accessible charging points. Other major cities like Munich and Stuttgart also offer high numbers of charging points, with 2,053 and 1,456 public charging points, respectively (Parklio, n.d.).

- Germany has been a leader in EV adoption within Europe. As of December 2025, the country had registered approximately 2.59 million EV cars (International Energy Agency, 2024).
- Germany is building up enablers such as hydrogen production and transportation, battery plants, and charging infrastructure (McKinsey & Company, 2021).

3.2. Public Transport and Modal Shifts

- **Immediate program for compliance with climate targets in the transport sector**: Expansion and quality offensive in local public transport: The federal government is currently supporting local public transport with financial means within the framework of the Municipal Transport Financing Act (GVFG), via the Regionalization Act and from other funding programs. In addition, further measures are to be agreed with the federal states with the aim of organizational improvements and simplification of the use of public transport (Climate Change Laws, 2022).
- **Rail Network:** Germany boasts an extensive rail network, with approximately 38,836 kilometers of railway lines in use as of 2022, making it the country with the longest rail network in Europe.
- **Public Transport Network:** In 2020, the total length of Germany's public land transport network, excluding regional trains, amounted to 273,296 kilometers. The urban bus network was the most extensive, representing almost 98% of this total (Statista, 2024). Germany's public transportation system relies heavily on two key rail-based networks: the U-Bahn and S-Bahn. The U-Bahn (short for *Untergrundbahn*, or underground railway) serves as the primary urban metro system, operating mainly in city centers with frequent service and short distances between stations. It exists in major cities like Berlin, Munich, Hamburg, Frankfurt, and Nuremberg. In contrast, the S-Bahn (*Stadtschnellbahn*, or city rapid railway) functions as a commuter rail network, linking city centers to suburban and surrounding areas, often sharing tracks with regional trains. Found in most large German metropolitan areas, the S-Bahn has fewer stops and longer distances between stations compared to the U-Bahn. Both systems are fully integrated into broader public transport associations (*Verkehrsverbünde*), allowing seamless travel with unified ticketing across buses, trams, and regional trains. Together, the U-Bahn and S-Bahn form the backbone of Germany's high-capacity, multimodal, and increasingly sustainable urban mobility infrastructure (Deutsche Bahn, n.d.).

- **Seventh Law amending the Regionalization Law (9-euro public transport ticket):** This law aims at bringing relief for citizens in using public transport by introducing a discounted monthly ticket for June, July and August 2022 ("9-Euro-Ticket") and to support the proportional compensation payments by increasing the regionalization funds to compensate for the financial disadvantages caused by the COVID-19 pandemic ("public transport rescue package") (Climate Change Laws, 2022).
- Germany boasts a well-developed public transportation network, including buses, trams, and trains. In 2022, the country recorded approximately 99.7 billion passenger-kilometers in urban public transit, marking a significant increase from 70.6 billion in 2021, which had been impacted by the COVID-19 pandemic. Despite this robust infrastructure, private vehicles remain the predominant mode of transport, accounting for about 47% of daily passenger trips per person in 2022. Recent trends indicate a decline in vehicle traffic, particularly in urban areas. Berlin, for instance, has seen a 12% reduction in traffic since 2019, attributed to factors such as increased hybrid working models, rising fuel prices, and the introduction of the "Deutschlandticket," offering unlimited travel on many routes for €58 per month (Statista, 2025).

3.3. Railway Decarbonization

- Deutsche Bahn, Germany's national railway company, has committed to achieving climate neutrality by 2040. The company is focusing on further electrification of its rail network, with over 90% of all rail transport services in Germany already electrified. For non-electrified routes, Deutsche Bahn is exploring alternative drives and fuels to replace fossil diesel (DB, n.d.).

3.4. Maritime and Aviation

- Germany is actively advancing decarbonization in both its maritime and aviation sectors to meet its national climate targets. In maritime transport, the government launched the National Action Plan for Climate-Friendly Shipping (NAPS) in 2024, focusing on green corridors, alternative fuels such as hydrogen and biofuels, and expanded shore-side power infrastructure. These efforts are complemented by the inclusion of shipping in the EU Emissions Trading System (EU ETS), incentivizing cleaner technologies. In aviation, Germany has set ambitious goals to produce up to 1.5 million tons of sustainable aviation fuel (SAF) annually by 2030, with a focus on Power-to-Liquid (PtL) fuels using green hydrogen. Although large-scale SAF production is still in development, the government is supporting the transition through repayable loans and compliance with EU-wide SAF blending mandates under the ReFuelEU Aviation regulation. However, the aviation industry, including IATA, has expressed concerns about rising aviation taxes potentially limiting investment in green technologies. Overall, Germany's dual-sector decarbonization strategy blends regulatory frameworks, financial tools, and innovation incentives to accelerate the transition to climate-neutral mobility (Federal Ministiry of Transport, n.d.).

- Germany is decarbonizing public maritime and aviation transport by transitioning ferries to electric and hydrogen power, expanding shore-side electricity at ports, and supporting fuel-cell ship projects (Federal Ministiry of Transport, n.d.). In aviation, it promotes Sustainable Aviation Fuels (SAF), invests in electric and hydrogen-powered aircraft for short-haul routes, and reduces emissions at airports through green operations. Additionally, Germany encourages rail-air integration to replace short domestic flights, all as part of its broader climate-neutral mobility strategy (Federal Ministry for Economic Affairs and Energy, n.d.).

4. Renewable Energy Integration

4.1. Fuel Mix

- Germany is actively working to integrate renewable energy into its transport sector. Deutsche Bahn aims to use 100% renewable power in all its depots, office buildings, and stations in Germany by 2025. Since 2019, 33 of its stations, including the 15 largest, have been using 100% renewable power (Climate Change Laws, 2022).

5. Economic and Social Factors

5.1. Affordability and Accessibility

- **Immediate program for compliance with climate targets in the transport sector**: Expansion of digital forms of work: The digitization push triggered by the corona pandemic (working from home instead of in the office) is to be strengthened by measures such as the legal basis for mobile working and the gigabit strategy of the federal government (Climate Change Laws, 2022).
- **Immediate program for compliance with climate targets in the transport sector**: Cycling infrastructure expansion initiative – active mobility: Strengthening of programs to promote cycling infrastructure, including the necessary communication and accompanying measures, as well as pedestrian traffic (additional requirement of around EUR 250 million by 2030) and other measures (Climate Change Laws, 2022).
- Germany introduced the Deutschlandticket, a flat-rate ticket for local and regional public transport, in May 2023. This initiative has improved affordability and accessibility of

public transport, leading to a shift from car use to train travel. The share of train journeys for distances over 30 kilometers increased from around 10% to 12% (Wettengel, 2024).

- Germany provides grants of up to €40,000 for zero-emission trucks, covering as much as 80% of the extra investment costs, with a total funding pool of €1.16 billion available through 2023 (Transport & Environment, 2021).

5.2. Job Creation

- Germany's transition to electric mobility is significantly impacting job creation within its transport sector, with Tesla's Gigafactory Berlin-Brandenburg serving as a prominent example. Located in Grünheide, Brandenburg, the facility began operations in March 2022 and currently employs approximately 12,000 workers, making it one of the largest industrial employers in the region. Initially, Tesla announced plans to create 3,000 jobs, with projections to expand up to 7,000 positions in subsequent phases. In October 2024, Tesla converted 500 temporary positions into permanent roles, reflecting a positive outlook on the growth of electric vehicle production (Wikipedia, 2025).
- The broader shift towards electric vehicles presents challenges for employment in Germany's automotive sector. A study by the German Institute for Employment Research (IAB) estimates that electrification could result in the loss of approximately 150,000 jobs by 2035, primarily due to the reduced labor requirements for electric powertrains compared to traditional combustion engines (Metta, et al., 2022)

5.3. Equity and Inclusion

- Germany promotes equity and inclusion in its transport sector through a strong legal framework, infrastructure improvements, and digital accessibility tools. The Equal Opportunities for Disabled Persons Act and amendments to the Passenger Transportation Act mandate accessible public services and local transport planning that accommodates individuals with disabilities. Public transport systems across Germany offer low-floor buses, trams with designated wheelchair areas, and free travel for persons with severe disabilities. Digital tools like Wheelmap.org further support mobility by identifying accessible locations. These measures, along with broader inclusive policies for housing and healthcare access, reflect Germany’s commitment to creating a more equitable and inclusive transport system (UsableNet, 2024), (Passionate People Team, n.d.), (Permanent Mission of the Federal Republic of Germany to United Nations, 2023).

6. International Collaboration and Financing

6.1. Participation in Global Initiatives

- Germany actively participates in several global initiatives aimed at decarbonizing the transport sector, aligning with its national goal of achieving climate neutrality by 2045.
- One significant engagement is through the Decarbonising Transport Initiative led by the International Transport Forum (ITF). This initiative provides policymakers with analytical tools and data to identify effective CO_2 mitigation strategies across various transport modes, including road, rail, aviation, and maritime. Germany collaborates with over 70 governments and organizations within this framework to develop evidence-based policies for reducing transport emissions (International Transport Forum, n.d.).
- In the maritime sector, Germany is a key participant in the Getting to Zero Coalition, a global alliance of stakeholders committed to deploying commercially viable zero-emission vessels by 2030. This coalition focuses on developing the necessary infrastructure for scalable zero-carbon energy sources, such as production, distribution, storage, and bunkering, to support the decarbonization of international shipping (Wikipedia, 2025).
- Through active participation in these global initiatives, Germany reinforces its commitment to reducing greenhouse gas emissions in the transport sector and contributes to the collective international effort to combat climate change.

6.2. Climate Finance:

- Germany is implementing a range of climate finance initiatives to support the decarbonization of its transport sector at both national and international levels. Domestically, the government has established the €100 billion Climate and Transformation Fund (KTF) to finance climate-related infrastructure, including sustainable mobility and low-emission transport systems. Additionally, the Climate Action Programme 2030 introduced a national carbon pricing scheme for the transport sector to incentivize cleaner alternatives. Internationally, Germany is a leading contributor to the International Climate Initiative (IKI), which has mobilized around €6 billion to help developing countries transition to low-carbon transport systems. Germany also supports the European Climate Initiative (EUKI), which has financed over 150 cross-border projects across Europe, promoting emission reductions in transport and other sectors. These efforts underscore Germany's commitment to using climate finance as a strategic tool to drive sustainable transport development both within its borders and globally (ESG News, 2025), (The Federal Goverment, n.d.), (Alvarez, Bongardt, & Eberhardt, 2022).

7. Innovation and R&D

7.1. Development of New Technologies

- Germany is investing in new technologies for transport decarbonization. For example, the country is pushing for the use of green hydrogen in transport, with 60 running projects for hydrogen production with renewables and another 80 being planned or constructed (Wehrmann, 2023).
- The government has initiated the "Power to the Road" project, aiming to establish a nationwide fast-charging network for heavy-duty electric vehicles. This initiative plans to create 350 fast-charging sites covering about 95% of Germany's federal highways, facilitating the adoption of battery-electric trucks in long-haul freight transport (Alkousaa, 2024). Recognizing the need to address emissions from hard-to-abate sectors, Germany's Federal Cabinet approved plans to allow carbon dioxide capture and storage for certain industrial sectors. This legal framework facilitates the development of CO_2 pipeline infrastructure and the storage of CO_2 in geological formations, such as under the North Sea (Reuters, 2024).
- Germany has introduced hydrogen-powered passenger trains, such as the Alstom Coradia iLint, which operate on hydrogen fuel cells emitting only water vapor. This technology offers a zero-emission alternative for non-electrified rail lines, contributing to the decarbonization of regional rail transport (Gray, 2022).

7.2. Patents and Innovation

- In 2023, the German Patent and Trade Mark Office (DPMA) received 58,656 patent applications, with 38,469 originating from domestic applicants—a 3.4% increase from the previous year. Notably, the transport and electrical machinery sectors were among the top fields for patent filings, particularly in the innovation hubs of Baden-Württemberg and Bavaria. Germany maintained its position as the top filer of transport-related patents in Europe during the first half of 2023, underscoring its leadership in this domain. The country’s innovation landscape includes advancements in battery-electric and hydrogen fuel cell technologies, as well as autonomous vehicle systems (German Patent and Trade Mark Office, 2024), (Composites United, 2024), (Blair, 2023).

7.3. Pilot Projects

- Germany is conducting various pilot projects in transport decarbonization. For instance, Deutsche Bahn is testing e-fuels on its advanced TrainLab and conducting research projects with industry partners for heavy haul traffic solutions, such as ammonia-powered trains (Fischer, 2023).

- Germany is also actively pursuing pilot projects to decarbonize urban mobility, integrating technological innovation with community engagement. In Dresden's Ostra district, initiatives are exploring Vehicle-to-Everything (V2X) technology, enabling electric vehicles to function as mobile energy storage units, thereby supporting grid stability and promoting sustainable mobility (Wang, Cabrera, & Fitzek, 2024).
- The city of Lindau is implementing artificial intelligence to monitor air quality, aiming to combat pollution from transportation sources (EIT Urban Mobility, 2023).
- In Bruchsal, the EfeuCampus project is testing autonomous delivery robots and emission-free cargo drones to revolutionize last-mile logistics. The CoLAB initiative, involving Aachen, Münster, and Mannheim, focuses on citizen-driven climate action, encouraging behavioral changes in mobility, energy use, and consumption through collaborative platforms (Peinhardt, 2023).

8. Performance of Key Transport Modes

8.1. Road Transport

- Road transport remains a significant contributor to Germany's transport emissions. The government has introduced measures such as a CO_2 surcharge on truck tolls to incentivize a shift to cleaner modes of transport (Meza, German govt agrees "green mobility update" in decarbonisation push for transport sector, 2023).

8.2. Public Transport:

- The introduction of the Deutschlandticket has significantly boosted public transport use in Germany. It helped reduce car emissions by 6.7 million tonnes of CO_2 between May 2023 and April 2024, representing almost 5% of annual transport sector emissions (Wettengel, 2024).

8.3. Railways

- The German rail network has a total route length of approximately 39,200 km in 2024 (International Trade Administration, 2024). Deutsche Bahn is making significant progress in decarbonizing its operations. All long-distance electric trains have been running on 100% green energy since 2018, and several regional lines have also been converted to 100% renewable power (D'Souza, 2023).

8.4. Aviation

- Germany is advancing aviation decarbonization through mandatory Sustainable Aviation Fuel (SAF) blending quotas—starting at 2% in 2025 and rising to 6% by 2030—alongside national targets for synthetic Power-to-Liquid (PtL) fuels. Despite strong policy support, including the National Hydrogen Strategy and collaborative industry efforts, the country faces challenges in scaling up SAF production and reducing high fuel costs, which currently limit large-scale adoption. Ongoing initiatives, such as the Climate-Neutral Aviation Working Group, aim to boost SAF availability, improve operational efficiency, and support research to meet Germany's long-term emission reduction goals in aviation (International Trade Administration, 2024), (Reuters, 2024), (Meza, 2025), (Pfeiffer & Spöttle).
- The Aviation Initiative for Renewable Energy in Germany (AIREG) targets substituting 10% of Germany's jet fuel consumption with sustainable alternative aviation fuels by 2025 (International Civil Aviation Organization, 2025).

8.5. Maritime

- Germany is actively decarbonizing its maritime sector through national strategies, innovative fuel technologies, and alignment with EU and international regulations. The government's National Action Plan for Climate-Friendly Shipping promotes alternative fuels, green corridors, and low-emission technologies, while companies like ICODOS and Hapag-Lloyd are pioneering the use of e-methanol and biomethane from organic waste. Germany also supports the EU's FuelEU Maritime Regulation, which targets an 80% reduction in shipping fuel emissions by 2050. Through its role in the Zero-Emission Shipping Mission, Germany is working toward making zero-emission vessels commercially viable by 2030 (Prevljak, Germany Accelerates Climate-Friendly Shipping Game, 2024), (Early & Slavin, 2025), (European Commission, 2023), (Mission Innovation, 2023).

3.3 Netherlands

The Netherlands leads Europe with 41% high-abated fuel use, making decarbonization a key priority. The Climate Act mandates a 49% GHG reduction by 2030 and 95% by 2050. To align with Europe's "Fit for 55," the Netherlands aims for a 55% reduction by 2030, with additional targets of 70% by 2035 and 80% by 2040 to reach Net Zero by 2050.

Transport emissions account for nearly 17% of total GHG emissions. The National Climate Action Plan includes: Zero-emission new public transport buses by 2025; A fully zero-emission bus fleet by 2030; All new passenger vehicles zero-emission by 2030.

The Netherlands is the first country to allow cities to implement zero-emission zones. The Ministry of Environment and 14 municipalities agreed to ban fossil fuel delivery vehicles by 2023. Amsterdam, Rotterdam, and Utrecht have designated "milieu zones" banning certain vehicles. To promote sustainable mobility, the central government collaborates with local governments and has made significant investments in public transport. All-electric passenger trains have been powered by green energy since 2017. The goal is for all vehicles on the road to have zero emissions by 2050.

The following Net Zero transport initiatives were carried out in Netherlands: Zero-Emission Zones - Cities like Amsterdam, Rotterdam, and Utrecht have established zero-emission zones, banning fossil fuel delivery vehicles to reduce urban emissions; Public Transport Electrification - All new public transport buses will be zero-emission by 2025, with a fully zero-emission bus fleet by 2030; EVs - The Netherlands aims for all new passenger vehicles to be zero-emission by 2030; Green Buses - The country is promoting green buses through investments and infrastructure enhancements; Sustainable Mobility - Significant investments in public transport and sustainable mobility options, such as cycling and walking infrastructure; Renewable Energy in Rail - All-electric passenger trains have been powered by green energy since 2017; Tax Incentives - Implementing tax incentives and adjustments to encourage the adoption of electric vehicles.

The Table 6 below summarizes the target details for different transport modes:

Table 6. Target Details for Different Transport Modes in Netherlands

NETHERLANDS [28] [29] [30]	
Transport Mode	**Target Details**
Road Transport[31]	**2030 Goals**: 49% emissions reduction from 1990 levels, focusing on phasing out Internal Combustion Engine (ICE) vehicles by 2030.
	2050 Goal: Full decarbonization of road transport through Electric Vehicles (EVs) and hydrogen, with robust cycling and walking infrastructure.
Public Transport[32]	**2030 Goals**: Transition to zero-emission buses and trains, especially within cities.
	2050 Goal: Complete electrification of public transit systems powered by renewable energy.
Rail Transport[33]	**2030 Goals**: Sustain full electrification of the passenger rail network, with additional investments in renewable energy. It is aimed to increase the use of hydrogen for passenger and freight transport over long distances.
	2050 Goal: Maintain zero-carbon rail transport, fully powered by green energy.
Aviation[34]	**2030 Goals**: 14% SAF use for all flights within Europe, with strict emission regulations.
	2050 Goal: Achieve net-zero for aviation through SAF, emerging tech, and strong emission regulations.
Maritime[35]	**2030 Goals**: Increase electric and LNG options for inland waterways, and shore-side power at ports.
	2050 Goal: Decarbonize all domestic shipping and ports using green hydrogen and other clean fuels.

[28] European Comission. (2021, July 21). Mobility Strategy. Retrieved September 3, 2025, from European Comission: https://transport.ec.europa.eu/transport-themes/mobility-strategy_en
[29] European Hydrogen Observatory. (2025, June 20). Sustainable and Smart Mobility Strategy. Retrieved September 3, 2025, from European Hydrogen Observatory: https://observatory.clean-hydrogen.europa.eu/eu-policy/sustainable-and-smart-mobility-strategy
[30] European Parliament. (2024). The Netherlands' Climate Action Strategy. European Parliament. Retrieved September 3, 2025, from https://www.europarl.europa.eu/RegData/etudes/BRIE/2024/767176/EPRS_BRI(2024)767176_EN.pdf
[31] Climate Change. (2017). Decarbonising Transportation in The Netherlands – A Policy Case Study. Climate Change. Retrieved September 3, 2025, from https://www.climatexchange.org.uk/wp-content/uploads/2023/09/eu_case_study_dutch_transportation.pdf
[32] Transport Energy Strategies. (2020, November 24). 2030 Climate Targets for Mobility in the Netherlands Require a Cap for the Use of Fossil Fuel. Retrieved September 3, 2025, from https://transportenergystrategies.com/2020/11/24/2030-climate-targets-for-mobility-require-a-cap-for-the-use-of-fossil-fuel/
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[35] UNFCCC secretariat. (2024). Multilateral Assessment . United Nation Climate Change.
United Nations. (2022, June 27). The Netherlands to work towards climate-neutral shipping in 2050. Retrieved September 3, 2025, from United Nations: https://sdgs.un.org/partnerships/netherlands-work-towards-climate-neutral-shipping-2050#description

Within the scope of examining the countries according to the benchmarking criteria, the information and documents of the following institutions were taken into consideration:

- The Ministry of Economic Affairs and Climate,
- The Ministry of Infrastructure and Water Management,
- The Netherlands Environmental Assessment Agency (PBL).

Benchmark Criteria for Netherlands

1. Policy and Regulatory Framework

1.1. National Targets and Strategies

- The Netherlands is committed to achieving net-zero greenhouse gas (GHG) emissions by 2050, aligning with the European Union's climate objectives. Intermediate milestones include a 49% emission reduction by 2030, with targeted reductions in energy and transport sectors.
- Sector-specific targets include zero-emission vehicle sales by 2040, renewable fuels for shipping, and full rail electrification with renewable power by 2030. There are also emissions intensity reduction goals for aviation under the CORSIA framework (Government of the Netherlands, n.d.).
- The country plans to implement zero-emission zones for urban logistics in at least 30 cities by 2025 (Wappelhorst, 2021).

1.2. Regulatory Measures

- EU emission standards (Euro 6/VI for vehicles) apply across the Netherlands, with stricter regulations in urban areas to reduce NOx and PM2.5 levels. Aviation and maritime emissions follow ICAO and IMO protocols (European Environment Agency, n.d.).
- The Netherlands mandates the blending of advanced biofuels in transport fuels and is scaling up green hydrogen projects for heavy transport and shipping. Incentives promote hydrogen refueling infrastructure development (European Commission, n.d.).
- The government has developed initiatives like the Car Sharing Green Deal to promote sustainable transport solutions (Transport Decarbonisation Alliance, n.d.).

1.3. Incentives

- Purchase subsidies of up to €4,000 are available for new electric vehicles (EVs), along with tax exemptions and grants for installing EV charging infrastructure (Rijksdienst voor Ondernemend Nederland, n.d.).
- R&D funding supports innovations in battery technology, hydrogen propulsion, and smart mobility solutions. The Top Sectors program collaborates with industry and research institutions (Top Sectoren, n.d.).

2. Emissions Performance

2.1. Transport Sector Emissions

- The transport sector contributes 29% of national emissions. Road transport accounts for the majority, followed by aviation and shipping (PBL Netherlands Environmental Assessment Agency, n.d.).
  Approximately 30% of total emissions are from transport activities, with policies in place to reduce this share through modal shifts and electrification (Government of the Netherlands, n.d.).

2.2. Emission Intensity

- Emissions intensity in passenger transport has declined due to increased EV adoption and public transport improvements. Freight transport efficiency remains a challenge (Eurostat, n.d.).
- CO_2 emissions per capita are among the highest in the EU, primarily due to high car ownership rates (European Environment Agency, n.d.).

2.3. Progress in Reducing Emissions

- A steady reduction in emissions has been observed, with an 8.1% annual decrease reported in 2022, driven by electrification and renewable energy integration.

3. Infrastructure and Technology

3.1. Electrification

- Over 13,000 public EV charging stations are available, giving the Netherlands one of the highest densities of charging infrastructure globally (Rijksdienst voor Ondernemend Nederland, n.d.).
- EVs make up 9.7% of registered vehicles, with targets to reach 100% zero-emission new car sales by 2030 (Rijksdienst voor Ondernemend Nederland, n.d.).

3.2. Public Transport and Modal Shifts

- Extensive rail and metro systems support high public transport usage, particularly in urban areas. The Netherlands is expanding these networks under the EU TEN-T program (European Commission, n.d.).
- Data shows that approximately 20% of passenger-kilometers are by public transport, with ongoing efforts to increase this share through multimodal integration (Government of the Netherlands, n.d.).
- The Netherlands leads globally in cycling, with over 27% of all trips made by bicycle. Continuous investments in safe, extensive cycling infrastructure and integration with public transport systems make cycling a key pillar of the country's sustainable mobility strategy (Goverment of Netherlands, 2018)

3.3. Railway Decarbonization

- 76% of the rail network is electrified, and operations are powered entirely by renewable electricity (Pro Rail, n.d.).
- The national rail operator, NS, sources 100% of its electricity from wind power (Nederlandse Spoorwegen, n.d.).

3.4. Maritime and Aviation

- LNG and hydrogen fuel initiatives are actively pursued in the shipping and aviation sectors through pilot projects and partnerships with stakeholders (Rijksdienst voor Ondernemend Nederland, n.d.).
- The Netherlands is accelerating the use of Sustainable Aviation Fuels (SAF) by mandating a 14% SAF blending obligation for all flights departing Dutch airports by 2030, supported by government subsidies and innovation programs (Deloitte, n.d.).
- Fleet modernization programs have improved fuel efficiency by adopting lighter materials, streamlined designs, and engine upgrades in both sectors (European Commission, n.d.).

4.Renewable Energy Integration

4.1. Fuel Mix

- Renewable energy accounts for 12% of transport energy use, with biofuels and electrification playing key roles (European Commission, n.d.).
- Advanced biofuels and hydrogen are being deployed in freight transport and shipping, supported by national and EU initiatives (Government of the Netherlands, n.d.).

- The electricity grid is progressively decarbonizing, with over 40% of power now sourced from renewables.
- The Netherlands has increased investments in renewable projects that support transport infrastructure, including solar-powered EV charging stations and hydrogen fuel production (Rijksdienst voor Ondernemend Nederland, n.d.).

5. Economic and Social Factors

5.1. Affordability and Accessibility

- Public transport is affordable due to government subsidies, with monthly commuter passes available at reduced rates (Government of the Netherlands, n.d.).
- Public and electric transport options are widely accessible in urban areas. However, efforts to expand services in rural regions are ongoing (Rijksdienst voor Ondernemend Nederland, n.d.).

5.2. Job Creation

- The shift to sustainable transport has created thousands of new jobs in EV manufacturing, infrastructure development, and renewable energy (Rijksdienst voor Ondernemend Nederland, n.d.).

5.3. Equity and Inclusion

- The government has implemented policies to provide affordable low-carbon transport options to marginalized communities, including subsidies for rural transportation (Government of the Netherlands, n.d.).

6. International Collaboration and Financing

6.1. Participation in Global Initiative

- The Netherlands actively participates in CORSIA and IMO initiatives, contributing to global decarbonization targets for aviation and shipping (International Civil Aviation Organization, n.d.).

6.2. Climate Finance

- Dutch transport projects receive significant funding from EU climate programs, including the Horizon Europe framework (European Commission, n.d.).

The Netherlands collaborates with other countries like Denmark, Norway and Belgium on transport decarbonization projects through EU and UN partnerships (United Nations, n.d.).

7. Innovation and R&D

7.1. Development of New Technologies

- Investments focus on developing next-generation batteries, hydrogen fuel cells, and autonomous vehicle technologies (Rijksdienst voor Ondernemend Nederland, n.d.).
- The country is encouraging radical fleet renewal in the aviation sector to introduce more fuel-efficient aircraft (Pronk, 2015).

7.2. Patents and Innovation

- Dutch companies and research institutions hold numerous patents in EV technologies and renewable fuels (Rijksdienst voor Ondernemend Nederland, n.d.).
- Several pilot programs are underway to test autonomous electric buses and hydrogen-powered trains in select regions (Rijksdienst voor Ondernemend Nederland, n.d.).
- The Netherlands is testing hydrogen-powered trains and autonomous electric buses as part of its sustainable transport initiatives. In Groningen, hydrogen train trials have shown promising results on non-electrified routes, though procurement challenges remain. Meanwhile, autonomous electric buses are being piloted at Amsterdam Schiphol Airport and in Rotterdam's ParkShuttle system, with both projects aiming to reduce emissions and integrate advanced mobility technologies into daily operations (Hive Mobility, n.d.) (Ewing, 2024).

8. Performance of Key Transport Modes

8.1. Road Transport

- EV and hybrid vehicle sales have grown steadily, now accounting for 15% of new vehicle registrations (Rijksdienst voor Ondernemend Nederland, n.d.).
- The Netherlands has set a deadline of 2030 to ban new ICE vehicle sales, with financial incentives accelerating the transition (Government of the Netherlands, n.d.).
- The country provides tax incentives for electric vehicles while imposing substantially higher taxes on gasoline and diesel cars (Wappelhorst, 2021).

8.2. Public Transport

- Many urban areas have already transitioned to electric bus fleets, with plans for full electrification by 2035 (Rijksdienst voor Ondernemend Nederland, n.d.).
- Ongoing efforts include replacing diesel buses with electric models and retrofitting older vehicles for improved efficiency (Rijksdienst voor Ondernemend Nederland, n.d.).
- Since 2015, Amsterdam Airport Schiphol has operated 35 electric buses, establishing it as Europe's largest charging hub for electric buses (Transport Decarbonisation Alliance, n.d.).

8.3. Railways

- The Netherlands is expanding its high-speed rail network as part of the EU Trans-European Transport Network (TEN-T). New routes aim to reduce intercity travel times and shift passenger demand from short-haul flights to rail (European Commission, n.d.). The Netherlands' rail network reached a length of 3,033 km in 2024 (ProRail, n.d.).
- Efficiency improvements in freight rail include optimizing rail logistics and investing in new rolling stock designed for lower energy consumption. These measures aim to increase the competitiveness of rail freight over road transport (Rijksdienst voor Ondernemend Nederland, n.d.).

8.4. Aviation

- The Netherlands is investing in the development and deployment of sustainable aviation fuels (SAFs), targeting 14% SAF usage by 2030. National initiatives support biofuel production and partnerships with aviation stakeholders (Rijksdienst voor Ondernemend Nederland, n.d.).
- Advanced air traffic management systems have been implemented to optimize flight paths, reduce fuel consumption, and minimize delays. These efforts align with EU Single European Sky objectives (European Commission, n.d.).
- The "Smart and Sustainable" action agenda, a public-private partnership including 20 Dutch transport organizations, seeks to reduce aviation emissions back to 2005 levels by 2030 (Pronk, 2015).

8.5. Maritime

- The Netherlands is fully compliant with the International Maritime Organization (IMO) carbon intensity targets. Measures include improving vessel design efficiency and increasing the use of alternative fuels (International Maritime Organization, n.d.).
- Dutch shipping companies are investing in LNG-powered vessels and exploring hydrogen-based propulsion systems. Pilot projects are underway to test the viability of zero-emission technologies in maritime transport (Rijksdienst voor Ondernemend Nederland, n.d.).

3.4 Spain

As of 2019, Spain accounts for approximately 9% of the European Union's total greenhouse gas (GHG) emissions. Between 2005 and 2019, the country reduced its emissions by 27%, thereby outperforming the EU average. The carbon intensity of the Spanish economy remains slightly below the EU average (European Parliamentary Research Service [EPRS], 2021).

Under the Paris Agreement, Spain's commitments are framed within the EU's joint Nationally Determined Contribution (NDC), through which the EU has pledged to achieve at least a 55% net reduction in GHG emissions by 2030 compared to 1990 levels. In this context, Spain's binding national target for non-ETS sectors is a 37.7% reduction by 2030 compared to 2005 levels (Effort Sharing Regulation [ESR], 2023 revision). Furthermore, Spain's updated National Energy and Climate Plan (NECP) (draft 2023) foresees a total emission reduction of 32% by 2030 compared to 1990 levels.

The transport sector constitutes the largest source of emissions in the country, accounting for 30.7% of total emissions. A significant share of transport emissions originates from passenger cars (57% of sectoral emissions) and trucks and vans (25%). The National Energy and Climate Plan (NECP) projects a reduction of 27 $MtCO_2e$ by 2030 as a result of measures promoting a shift towards low- and zero-emission modes of transport. These measures include the establishment of low-emission zones in cities with more than 50,000 inhabitants from 2023 onwards, as well as increasing the share of renewable energy in the transport sector. Through electrification and the expanded use of advanced biofuels, the share of renewables in transport is expected to reach 28% by 2030. Average emissions from new passenger cars have remained below the EU-wide 2015 target of 130 g CO_2/km since 2012. However, the upward trend observed since 2016 has distanced Spain from the EU-wide target of 95 g/km set for 2021 (Ministry of Transport and Sustainable Mobility of Spain [MITMA], 2025).

By 2050, Spain's net greenhouse gas emissions are expected to decrease to 2.9 tonnes per capita.

In 2021, the government finalized the Sustainable Mobility and Public Transport Financing Act. With regard to the energy transition, forthcoming policy instruments include the National Fund for the Sustainability of the Electricity System, a national energy storage strategy, and a national self-consumption strategy. The Table 7 below summarizes the target details for different transport modes:

Table 7. Target Details for Different Transport Modes in Spain

SPAIN [36] [37]	
Transport Mode	**Target Details**
Road Transport[38]	**2030 Goal:** Reach 5.5 million electric vehicles (EVs) by providing incentives to phase out the use of internal combustion engine (ICE) vehicles.
	2050 Goal: Achieve 100% decarbonisation of passenger cars, light commercial vehicles, and motorcycles by 2050.
Public Transport[39]	**2030 Goal:** Transition to zero-emission buses in urban areas and promote electric and hydrogen-based public transport solutions.
	2050 Goal: Establish a fully decarbonised public transport system, particularly in urban areas, powered by renewable energy sources.
Rail Transport[40]	**2030 Goals**: Continue the electrification of the rail network, with a particular focus on increasing the modal share of rail freight transport relative to road transport.
	2050 Goal: Maintain a zero-carbon rail transport system fully powered by renewable energy sources.
Aviation[41]	**2030 Goal:** Increase the use of Sustainable Aviation Fuel (SAF) in domestic flights and ensure alignment with EU carbon reduction standards.

[36] European Comission. (2021, July 21). Mobility Strategy. Retrieved September 3, 2025, from European Comission: https://transport.ec.europa.eu/transport-themes/mobility-strategy_en

[37] European Hydrogen Observatory. (2025, June 20). Sustainable and Smart Mobility Strategy. Retrieved September 3, 2025, from European Hydrogen Observatory: https://observatory.clean-hydrogen.europa.eu/eu-policy/sustainable-and-smart-mobility-strategy

[38] McKinsey & Company. (2022). Net-Zero Spain: Europe’s Decarbonization Hub. McKinsey & Company. Retrieved September 3, 2025, from https://www.mckinsey.com/~/media/mckinsey/business%20functions/sustainability/our%20insights/net%20zero%20spain%20europes%20decarbonization%20hub/net-zero-spain-europes-decarbonization-hub-vfinal.pdf

[39] Climate Change Laws of The World. (2020, November). Long Term Decarbonisation Strategy 2050 (ELP 2050). Retrieved September 3, 2025, from Climate Change Laws of The World: https://climate-laws.org/document/long-term-decarbonisation-strategy-2050-elp-2050_0b6c

[40] Asuene. (2025, June 25). Decarbonizing Rail: How EU Green Deal’s Mobility Strategy Is Driving Low-Emission Transportation. Retrieved September 3, 2025, from Asuene: http://asuene.com/us/blog/decarbonizing-rail-how-eu-green-deals-mobility-strategy-is-driving-low-emission-transportation

[41] European Commisson. (n.d.). Reducing Emissions From Aviation. Retrieved September 3, 2025, from European Commisson: https://climate.ec.europa.eu/eu-action/transport-decarbonisation/reducing-emissions-aviation_en

SPAIN [36] [37]	
	2050 Goal: Achieve further emission reductions in domestic aviation through the increased use of biofuels (targeting 60% market penetration by 2050) and synthetic-fuel aircraft (targeting a 20% market share by 2050).
Maritime[42]	**2030 Goal**: Transition domestic waterways from LNG to sustainable e-fuels (such as e-methanol and e-ammonia) and expand shore-side electricity infrastructure at ports.
	2050 Goal: Fully decarbonise domestic maritime activities and ports through the use of green hydrogen and other clean fuels, achieving carbon neutrality by 2050.

Within the scope of examining the countries according to the benchmarking criteria, the information and documents of the following institutions were taken into consideration:

- Ministry of Transport, Mobility, and Urban Agenda (MITMA),
- Ministry for Ecological Transition and the Demographic Challenge,
- Institute for the Diversification and Saving of Energy (IDAE),
- Ports of Spain (Puertos del Estado),
- Transport & Environment Spain (NGO).

Benchmark Criteria for Spain

1. Policy and Regulatory Framework

1.1. National Targets and Strategies

- Spain aims to achieve net-zero emissions by 2050 and to reduce greenhouse gas emissions by 23% by 2030 compared to 1990 levels. The decarbonisation of transport constitutes a central pillar of this strategy (Ministerio para la Transición Ecológica y el Reto Demográfico, n.d.).
- Spain targets 100% electrification of rail services by 2030 and an increased use of alternative fuels in the aviation and maritime sectors. In road transport, the objective focuses on the gradual phase-out of internal combustion engine vehicles by 2040.

[42] Ministry for Ecological Transition and the Demographic Challenge. (2022). Roadmap Offshore Wind and Marine Energy in Spain. Madrid: Ministry for Ecological Transition and the Demographic Challenge. Retrieved September 2025, from https://www.miteco.gob.es/content/dam/miteco/es/ministerio/planes-estrategias/desarrollo-eolica-marina-energias/enhreolicamarina-pdf_accesible_tcm30-538999.pdf

1.2. Regulatory Measures

- Spain adheres to EU emission standards for vehicles (Euro 6/VI) and enforces regulations for cleaner fuels in aviation and shipping through ICAO and IMO frameworks (European Environment Agency, n.d.).
- Renewable energy mandates include a minimum blending requirement for advanced biofuels in road transport. Spain is also investing in hydrogen infrastructure for heavy transport and shipping (Ministry of Foreign Affairs of Denmark, n.d.).

1.3. Incentives

- Subsidies for electric vehicles (up to €7,000 per vehicle) and grants for charging infrastructure are provided under Spain's national mobility plan (MOVES III) (Ministerio para la Transición Ecológica y el Reto Demográfico, n.d.).
- Research funding focuses on EV batteries, hydrogen propulsion, and smart mobility innovations. Public-private partnerships drive technological advancements (Ministerio de Ciencia, Innovación Y Universidades, n.d.).

2. Emissions Performance

2.1. Transport Sector Emissions

- Transport accounts for approximately 30,7% of Spain's total GHG emissions, with road transport being the largest contributor (**Ministry of Transport and Sustainable Mobility of Spain** [MITMA], 2025).
- Transport emissions represent over a quarter of national GHG emissions, driven by high reliance on road vehicles (Eurostat, n.d.).

2.2. Emission Intensity

- Emission intensity has decreased due to investments in rail electrification and urban public transport systems. Freight transport remains a priority for further reduction.
- Spain's CO_2 emissions per capita are declining but remain above the EU average. Efforts focus on modal shifts and EV adoption (European Environment Agency, n.d.).

2.3. Progress in Reducing Emissions

- A 10% reduction in transport emissions was achieved from 2010 to 2020, largely driven by increased use of renewable energy and public transport improvements (Ministerio para la Transición Ecológica y el Reto Demográfico, n.d.).

3. Infrastructure and Technology

3.1. Electrification

- Electric and hybrid vehicles account for approximately 8% of new vehicle sales and are experiencing rapid growth, supported by government incentives.
- According to 2025 data, Spain's charging infrastructure corresponds to approximately 85–91 publicly accessible charging points per 1,000 plug-in vehicles. As of the third quarter of 2025, the Asociación Española de Fabricantes de Automóviles y Camiones (ANFAC) reports 52,107 public charging points, while the Asociación Empresarial para el Desarrollo e Impulso de la Movilidad Eléctrica (AEDIVE) reports 48,594 (ANFAC, 2025; AEDIVE, 2025).

3.2. Public Transport and Modal Shifts

- Major cities like Madrid and Barcelona have extensive metro and rail networks. National plans aim to further expand high-speed rail under the EU TEN-T initiative (European Commission, n.d.).
- Public transport accounts for 25% of passenger-kilometers, with targeted investments to increase ridership through improved accessibility and service frequency.

3.3. Railway Decarbonization

- Approximately 70% of Spain's rail network is electrified, with a target to reach 100% by 2030 (Adif, n.d.).
- National rail operator Renfe sources 100% of its electricity from renewable energy, with plans for full renewable sourcing by 2025 (Renfe, n.d.).

3.4. Maritime and Aviation

- Spain is piloting hydrogen-powered buses and promoting LNG in maritime transport. Partnerships with aviation stakeholders support sustainable aviation fuel (SAF) development (Ministry of Foreign Affairs of Denmark, n.d.).
- Spain's shipping and aviation industries are adopting lightweight materials and optimized engine designs to enhance fuel efficiency (European Commission, n.d.).

4. Renewable Energy Integration

4.1. Fuel Mix

- Renewable energy accounts for 14% of Spain's transport energy consumption, with significant contributions from biofuels and electrification (Ministerio para la Transición Ecológica y el Reto Demográfico, n.d.).
- Spain leads in the production and use of advanced biofuels and is scaling up green hydrogen projects for heavy transport (Ministry of Foreign Affairs of Denmark, n.d.).
- The carbon intensity of electricity has declined due to increased investments in solar and wind power, with over 56,8% of electricity now sourced from renewables (Ministry of Foreign Affairs of Denmark, n.d.).
- Spain has allocated €4 billion in funding for renewable energy projects supporting transport, including solar-powered EV charging stations and hydrogen refueling infrastructure (Ministerio para la Transición Ecológica y el Reto Demográfico, n.d.).
- The country is focusing on electrofuels, aiming for 28% eSAF usage by 2050 (Jané, 2024).

5. Economic and Social Factors

5.1. Affordability and Accessibility

- Public transport remains affordable, supported by targeted subsidies and incentive schemes for low-income households and students. Regional travel cards offer unlimited travel at discounted fares.
- Efforts to expand low-carbon mobility options focus on strengthening rural connectivity through the development of new bus services and enhanced rail links.
- Two distinct mechanisms are currently in place in Spain to support individual purchases of electric vehicles: (i) the direct grant scheme under Plan MITMA III, extended until 31 December 2025, provides up to €7,000 for passenger BEVs (including scrappage incentives), as well as support for charging infrastructure; and (ii) a 15% personal income tax (IRPF) deduction has been reinstated for 2025. The maximum eligible base for the deduction is €20,000, corresponding to a practical maximum tax benefit of €3,000. This incentive may be combined with MITMA III support, subject to compliance with eligibility conditions.

5.2. Job Creation

- Thousands of new jobs have been created in EV manufacturing, infrastructure development, and renewable energy projects (Ministerio de Ciencia, Innovación Y Universidades, n.d.).

5.3. Equity and Inclusion

- Policies aim to improve access to sustainable transport for marginalized communities through targeted investments and fare reductions (Ministerio para la Transición Ecológica y el Reto Demográfico, n.d.).

6. International Collaboration and Financing

6.1. Participation in Global Initiative

- Spain actively participates in global decarbonization initiatives, including CORSIA and IMO regulations (International Civil Aviation Organization, n.d.).

6.2. Climate Finance

- Spain benefits from EU funding under the Horizon Europe and Connecting Europe Facility programs (European Commission, n.d.).
- Spain collaborates with EU and Latin American partners on transport decarbonization projects (European Commission, n.d.).

7. Innovation and R&D

7.1. Development of New Technologies

- Spain’s investment in transport R&D includes funding for battery development, hydrogen propulsion systems, and autonomous vehicles (Ministerio de Ciencia, Innovación Y Universidades, n.d.).

7.2. Patents and Innovation

- Spanish research institutions and companies hold several patents in EV and hydrogen technologies (Oficina Española de Patentes y Marcas, n.d.).
- Pilot projects are underway to deploy autonomous electric buses in major cities and test hydrogen-powered trains in select regions.

8. Performance of Key Transport Modes

8.1. Road Transport

- EVs and hybrids represent 8% of new vehicle registrations, with growth driven by government incentives and infrastructure expansion (Ministry of Foreign Affairs of Denmark, n.d.).
- Spain has set a target to phase out ICE vehicles by 2040, with intermediate milestones for fleet electrification (Ministerio para la Transición Ecológica y el Reto Demográfico, n.d.).

8.2. Public Transport

- Urban areas are transitioning to electric buses, with over 1,000 deployed nationwide. Plans call for full electrification of city bus fleets by 2035.
- Efforts include replacing aging diesel buses with electric models and retrofitting vehicles for better fuel efficiency.

8.3. Railways

- Spain's high-speed rail network (AVE) is one of the largest in Europe, with ongoing expansions to improve connectivity and reduce short-haul flights (European Commission, n.d.). Spain's national rail network spans 16.026 km in total. Of this, 10.182 km are electrified, i.e. approximately 63.6 % of the network (Wikipedia, 2025).
- Investments in freight rail include new logistics hubs and energy-efficient locomotives to increase competitiveness with road transport (Adif, n.d.).

8.4. Aviation

- Spain is advancing SAF adoption through partnerships with airlines and biofuel producers, aiming for 10% SAF use by 2030 (Ministry of Foreign Affairs of Denmark, n.d.).
- Spain's air traffic management system is being modernized to reduce fuel consumption and delays, aligning with EU Single European Sky goals (European Commission, n.d.).

8.5. Maritime

- Spain complies with IMO regulations by adopting energy-efficient ship designs and alternative fuels (International Maritime Organization, n.d.).
- Spain is piloting LNG and hydrogen-powered ships to reduce maritime emissions.

- The Port of Valencia has adopted a strategy aiming for zero emissions by 2030, emphasizing decarbonization and digital innovation (World Ports Sustainability Program, n.d.).

4 SELECTED DEVELOPING COUNTRIES FOR BENCHMARKING

4.1 China

China has implemented a national strategy of proactively responding to climate change prioritizing it within the National Governance System. Since the Paris Agreement on climate change, China has actively updated its National Determined Contributions (NDCs) goals. In 2021, the carbon intensity of China decreased by 3.8% compared to 2020 and 50.8% relative to 2005 levels. Addressing climate change remains a high priority for the Chinese government. In 2020, China has declared to “peak carbon dioxide emissions before 2030 (including the transport sector)” and “achieve carbon neutrality before 2060”. China has outlined basic policies, a strategic vision and a technical pathway for mid-century long-term low greenhouse gas emission development, identifying strategic priorities in 10 key areas, including transportation.

China has actively promoted energy-saving and low-carbon technologies and maintained a rapid growth in the new-energy vehicle sector (NEV). It has increased its cumulative sales of NEVs to over 10 million units and elevated the adoption of new-energy buses nationwide to more than 71%. China has prioritized LNG-powered ships for passage through the Three Gorges ship lock, established an initial LNG refilling system, and constructed over 310 LNG-powered inland ships. China has pushed ahead with the electrification of existing railways has advanced, with the railway electrification rate reaching 73.3% by 2021, which contributed to a 3.9% reduction in overall energy consumption per unit railway transport workload from the previous year. In civil aviation, China has implemented green development programs and supported the rapid expansion of airport electrification. By the end of 2021, the share of electric vehicles at airports had risen to 21%, with Beijing Daxing International Airport nearing 80%, adoption rate for EVs. The installation and utilization rates of alternative devices to aircraft auxiliary power units (APU) at airports handling over 5 million annual passengers reached 95%, saving approximately 640,000 tons of aviation fuel since 2018. China has also shifted cargo transportation from road to rail and waterway modes significantly; in 2021, rail freight volume increased by 4.9% year on year to 4.774 billion tons, waterway freight volume rose by 6.8% to 15.545 billion tons, and rail-water intermodal transportation grew by 9.8% to 7.54 million TEUs.

Moreover, China has fully embraced a strategy that prioritized urban public transport, expanded accessible public transport services nationwide, advocated for green travel, and continuously improved the green travel experience. The development of green transportation infrastructure has accelerated, with the deployment of 2.617 million charging points and more than 200 hydrogen refueling stations across the country.

The Table 8 below summarizes the target details for different transport modes:

Table 8. Target Details for Different Transport Modes in China

CHINA [43] [44]	
Transport Mode	**Target Details**
Road Transport[45]	**2030 Goals:** Implement advanced policy measures including the expansion of Electric Vehicles (EVs) fleets in private and commercial sectors. Increase the share of new energy vehicles to 40% of new car sales.
	2050 Goal: Achieve a major reduction in road transport emissions through widespread adoption of electric and hydrogen fuel cell vehicles.
Public Transport[46]	**2030 Goals**: Expand electric and hybrid bus fleets in major cities, targeting over 50% electrification of new bus purchases.
	2050 Goal: Fully decarbonize public transport systems by expanding electric rail networks and achieving 100% electrification of urban buses.
Rail Transport[47]	**2030 Goals**: Continue to expand electrification of new rail lines and upgrade existing ones.
	2050 Goal: Complete the electrification of all rail transport and reduce GHG emissions by 80% compared to 2020 levels through technological advancements and increased energy efficiency.
Aviation[48]	**2030 Goals**: Implement measures to increase energy efficiency and initiate adoption of Sustainable Aviation Fuels (SAF).
	2050 Goal: Implement widespread use of SAF and develop electric or hybrid aircraft technologies to achieve net-zero emissions in domestic flights.

[43] Jin, L., Saho, Z., Mao, X., Miller, J., He, H., & Isenstadt, A. (2021). Opportunities and Pathways to Decarbonize China's Tansportation Sector During the Fourteenth Five-Year Plan Period and Beyond. The International Council on Clean Transportation. Retrieved from https://theicct.org/wp-content/uploads/2021/12/China-14th-FYP-Report-v8-nov21.pdf

[44] China Academy of Transportation Sciences. (2021). Report on Sustainable Transport in China. Retrieved September 3, 2025, from https://xxgk.mot.gov.cn/jigou/gjhzs/202112/P020211214343055452953.pdf

[45] The Oxford Institute for Energy Studies. (2025). Rising New Energy Vehicle Sales in China: Falling Gasoline Demand, Rising Uncertainty. The Oxford Institute for Energy Studies. Retrieved September 3, 2025, from https://www.oxfordenergy.org/wpcms/wp-content/uploads/2025/04/Insight-167-Rising-new-energy-vehicle-sales-in-China.pdf

[46] Jin, L., Saho, Z., Mao, X., Miller, J., He, H., & Isenstadt, A. (2021). Opportunities and Pathways to Decarbonize China's Tansportation Sector During the Fourteenth Five-Year Plan Period and Beyond. The International Council on Clean Transportation. Retrieved from https://theicct.org/wp-content/uploads/2021/12/China-14th-FYP-Report-v8-nov21.pdf

[47] Word Resources Institute China. (2022). Decarbonizing China's Road Transport Sector: Strategies toward Carbon Neutrality. Chine: WRI China. Retrieved September 2, 2025, from https://www.wri.org/research/decarbonizing-chinas-road-transport-sector-strategies-toward-carbon-neutrality

[48] Ma, D. (2024, December 12). COMMENTARY: China's fair and equitable solution to civil aviation's climate challenge. Retrieved March 25, 2025, from Green Air: https://www.greenairnews.com/?p=6331

Maritime[49]	**2030 Goals**: Increase the number of shore power facilities and incentivize the transition to cleaner fuel options in domestic shipping.
	2050 Goal: Achieve a significant reduction in maritime emissions by promoting the adoption of green fuels and advanced energy systems in international and domestic fleets.

Within the scope of examining the countries according to the benchmarking criteria, the information and documents of the following institutions were taken into consideration:

- Ministry of Ecology and Environment of the People's Republic of China.
- Ministry of Transport of the People's Republic of China.
- Ministry of Energy of the People's Republic of China.

Benchmark Criteria for China

1. Policy and Regulatory Framework

1.1. National Targets and Strategies

- China has set ambitious targets for decarbonizing its transport sector as part of its broader climate goals. The country aims to achieve carbon neutrality by 2060. For the transport sector specifically, projections indicate that emissions are likely to peak between 2025 and 2035, potentially before 2030 if effective policies are implemented (World Resources Institute China, 2022) (Word Resources Institute China, 2022). China also aims to increase the share of non-fossil fuels in primary energy consumption to 18.9% in 2024 and 20% in 2025 (Climate Cooperation China, 2024).
- China plans to reach 15 million plug-in electric vehicles by 2030, setting ambitious goals for new energy vehicle (NEV) sales (Yu, 2023).

1.2. Regulatory Measures

China has implemented several regulatory measures to support its transport decarbonization goals:

- The Revolutionary Strategy for Energy Production and Consumption (2016-2030) (Xue & Liu, 2022).

[49] Mao, X., & Meng, Z. (2022). Decarbonizing China's coastal shipping: The role of fuel efficiency and low-carbon fuels. Retrieved September 3, 2025, from https://theicct.org/wp-content/uploads/2022/06/china-marine-decarbonizing-chinas-coastal-shipping-jun22.pdf

- The National Planning Outline of a Three-Dimensional Transportation Network (Xue & Liu, 2022).
- The "14th Five-Year" Modern Comprehensive Transportation System Development Plan (Xue & Liu, 2022).
- An Action Plan for Energy Saving and Carbon Reduction (July 2024), aiming to reduce energy consumption by 2.5% and CO_2 intensity by 3.9% by the end of 2024 (Climate Cooperation China, 2024).

1.3. Incentives

China is implementing various incentives to promote cleaner transport (e.g. tax exemptions, trade-in subsidies and local incentives for EVs; regional support for hydrogen energy development and; scrappage programs for fleet modernization):

- A full exemption of the 10 % purchase tax for new energy vehicles (NEVs) in 2024–2025 and a 50 % tax cut (up to ¥15 000) for NEVs bought in 2026–2027 (Xinhua, 2023).
- A “cash-for-clunkers” subsidy of up to ¥20 000 when trading in an old car for a new NEV (Xinhua, 2024).
- Local bonuses of ¥2 000–5 000 for EVs equipped with Huawei’s HarmonyOS in select municipalities (Yang, 2025).
- Provincial grants of up to ¥20 million for hydrogen production facilities, refueling stations and fuel-cell R&D (Fuel Cells Works, 2024).
- Expanded fleet-scrappage incentives under the national Large-scale Equipment Renewal and Trade-in Policies to retire outdated heavy trucks and buses (Pei, 2025).
- Gradual lifting of restrictions on purchasing new-energy vehicles in various regions
- Accelerating the elimination of old motor vehicles (Climate Cooperation China, 2024).
- Tightening energy consumption limits for operating vehicles (Climate Cooperation China, 2024).

2. Emissions Performance

2.1. Transport Sector Emissions

- The transport sector accounted for about 8.3% of China's total CO_2 emissions in 2022. Road transport is the largest contributor, accounting for 86.76% of the transport sector's emissions in 2019 (Gu, Jiang, Zhang, & Jiang, 2024), (International Energy Agency, n.d.).

2.2. Emission Intensity

- The annual growth rate of energy consumption in the transport sector reached 8.92% during 2000–2019. Diesel and gasoline combined consumption exceeds 70% in the transport sector (Gu, Jiang, Zhang, & Jiang, 2024).

2.3. Progress in Reducing Emissions

- Although China's transport carbon emissions have been increasing, the growth rate has declined since 2013 (Gu, Jiang, Zhang, & Jiang, 2024). If China implements its stated policies, road transport emissions could peak before 2030 and petroleum consumption before 2027. With more proactive measures, GHG emissions could peak by 2025 and petroleum consumption by 2024 (Xue & Liu, 2022).

3. Infrastructure and Technology

3.1. Electrification

- China has established itself as the world's largest electric vehicle market. The share of EVs out of all vehicles produced increased from 5% in 2019 to 30% in the 12 months up to August 2023 (Myllyvirta & Qin, China's Climate Transition Outlook 2024, 2024). The country is rapidly expanding its charging infrastructure to support the growing fleet of electric vehicles (Word Resources Institute China, 2022).
- China leads the global electric vehicle (EV) sector, accounting for approximately 58% of worldwide EV production in 2023. In 2024, the country sold around 12.87 million passenger EVs, with battery electric vehicles (BEVs) comprising 60% and plug-in hybrid electric vehicles (PHEVs) 40% of these sales. This surge reflects a significant increase from 2020, when plug-in vehicles represented only 6.3% of total sales (Wikipedia, 2025), (Wikipedia, 2025).
- China's dominance extends to the EV battery supply chain, producing over 60% of the world's EV batteries. The country houses more than half of the global processing and refining capacity for essential battery materials like lithium, cobalt, and graphite, contributing to lower EV production costs (Wikipedia, 2025).
- In terms of charging infrastructure, China operates the world's largest network, with over 3.6 million public charging stations as of late 2024, representing nearly 70% of the global total.

The government continues to expand this network, aiming to support the growing EV market and alleviate range anxiety among consumers (Kang, 2024).

- The country is speeding up the electrification of road freight, concentrating on battery-electric technologies and innovative approaches such as catenary trucks for long-distance transport (Ibold & Yun, 2021).

3.2. Public Transport and Modal Shifts

- China has invested heavily in public transport infrastructure. For example, Shanghai has issued a plan to promote solar energy deployment in its transport sector, aiming to add 120-180 MW of capacity by 2025 (Word Resources Institute China, 2022).

3.3. Railway Decarbonization

- China is actively working on decarbonizing its railway system. The electrification rate of railways reached 74.9% by 2021, with plans to increase this to 80% by 2025. The country is also researching the integration of photovoltaics to power the railway system (Jia, Cheng, Zhang, Ji, & Xu, 2022).

3.4. Maritime and Aviation

- Limited information is available regarding maritime and aviation decarbonization efforts in China.

4. Renewable Energy Integration

4.1. Fuel Mix

- China is actively promoting the integration of renewable energy into its transport sector. The share of electricity in transport energy use rose from 3.4% in 2018 to 4.8% in 2024 (Myllyvirta & Qin, China's Climate Transition Outlook 2024, 2024). Natural gas and liquefied petroleum gas (LPG) show the fastest growth rate in transport energy consumption, while raw coal consumption is decreasing, indicating an optimization of the transportation energy structure (Gu, Jiang, Zhang, & Jiang, 2024).

5. Economic and Social Factors

5.1. Affordability and Accessibility

- China has made significant strides in enhancing the affordability and accessibility of its public transportation system. As of 2022, approximately 90% of urban residents have convenient access to public transport, a figure that surpasses many global counterparts, including major cities in the United States. This extensive coverage is facilitated by China's expansive urban rail networks, which, by December 2024, encompassed over 11,000 kilometers across 47 cities. Affordability is maintained through government subsidies and distance-based fare systems; for instance, the Beijing Subway charges a base fare of ¥3 (approximately $0.41 USD) for journeys under 6 kilometers, with incremental increases for longer distances (Bela, 2024), (Wikipedia, 2025), (Kong, Pojani, Sipe, & Stead, 2021).
- The government unveiled a four-year, 520 billion yuan tax incentive program offering tax reductions for EVs and other eco-friendly vehicles (Interesse G. , 2023).

5.2. Job Creation

- China's transport and logistics sector has shown some fluctuations in job creation. In January 2024, there were 1,894 active job postings in the sector, representing a decrease of 11% month-over-month and 12.15% since October 2023. The number of new jobs posted decreased by 26.54% between October 2023 and January 2024, while the number of jobs closed increased by 37.35% during the same period (Global Data, 2022).

5.3. Equity and Inclusion

- China has taken steps to improve equity and inclusion in its transport sector by enhancing accessibility for persons with disabilities, the elderly, and other vulnerable groups. Urban transit systems like the Beijing Subway now feature elevators, ramps, priority seating, and audio announcements to support inclusive travel. Legal protections, such as the Law on the Protection of Disabled Persons, mandate accessible infrastructure. However, disparities persist, especially for low-income and low-mobility populations in suburban and rural areas, where commute times are longer and public transport access is limited (Wikipedia, 2025) (Wikipedia, 2025) (Ren, Zhang, Xu, & Yang, 2018).

6. International Collaboration and Financing

6.1. Participation in Global Initiatives

- China has been actively participating in global climate initiatives, particularly through its Belt and Road Initiative (BRI). The BRI, announced by Xi Jinping in 2013, is a global infrastructure development strategy designed to boost trade and economic growth (Zi, 2024).

6.2. Climate Finance

China has contributed significantly to global climate finance, particularly in developing countries:

- Since the launch of the Belt and Road Initiative, China has contributed over USD 30 billion to global climate finance (Zi, 2024).
- China ranks as the joint fifth-largest provider of climate finance after Japan, Germany, the United States, and France (Zi, 2024).
- China has delivered 10% of the $3.1 billion pledged for a dedicated fund to finance climate cooperation with the Global South in the seven years since its launch (Tsang, Schape , & Hackbarth, 2023).
- China spent over $1 billion a year on average on climate-related projects in the Global South between 2013 and 2017 (Tsang, Schape , & Hackbarth, 2023).
- By the end of October 2018, China had invested in 20 clean transportation projects and 31 clean energy projects in BRI countries (Hong, n.d.).

7. Innovation and R&D

China is advancing its transport decarbonization through the development of new technologies, robust patent activity, and extensive pilot projects.

7.1. Development of New Technologies

- China is actively researching and developing technologies to integrate renewable energy with transportation systems. This includes the promotion of electric vehicles (EVs), hydrogen fuel cell vehicles, and the electrification of heavy-duty trucks. The country aims to establish a modern energy system for the transport sector by 2035, focusing on clean and low-carbon energy consumption, technological innovation, and green, smart, and efficient practices. Chinese institutions account for 65% of high-impact research publications on electric batteries, significantly outpacing the United States' 12%. This reflects China's dominant position in both the quantity and quality of scientific research in this domain (The State Council The People's Republic of China, 2025), (Ezell, 2024), (Xue & Liu, 2022).

7.2. Patents and Innovation

- China has become a global leader in green and low-carbon technology patents. In the field of green hydrogen, Chinese firms have surpassed Japan in patent filings, ranking first in overall competitiveness and in categories such as production, storage, transport and supply, and safety management. Additionally, China's green patent system has promoted significant advancements in green technologies through accelerated patent examination mechanisms and policy incentives (Reccessary, 2025), (Xu , Xie, & Ying, 2024).

7.3. Pilot Projects

- China is implementing various pilot projects to test and scale renewable energy applications in transportation. For instance, the country plans to launch pilot projects in nine cities to utilize electric vehicles as batteries to stabilize the power grid during peak demand periods. These projects will primarily feature vehicle-to-grid (V2G) technology, where cars store and return electricity to the grid and adjust their charging times to avoid peak hours. Furthermore, China's new renewable energy plan encourages pilot projects focusing on emerging technologies, such as floating offshore wind farms and green hydrogen production, to drive innovation and help refine scalable models for clean energy substitution (Interesse G. , 2024), (Howe, 2025).

8. Performance of Key Transport Modes

8.1. Road Transport

- Road transport is a significant contributor to China's transport emissions, accounting for 86.76% of the transport sector's emissions in 2019.

8.2. Public Transport

- China's public transport system is one of the largest and most efficient in the world, serving around 90% of urban residents through an extensive and expanding network of subways, light rail, and streetcars. Cities like Beijing and Shanghai handle millions of daily passengers, with metro fares kept low—typically ¥2 to ¥6—ensuring affordability and accessibility. The system benefits from continuous investment, technological integration, and strong ridership performance, though challenges remain in addressing the mobility needs of low-income and suburban populations (Bela, 2024), (Zhou, et al., 2022).

8.3. Railways

- China has made significant investments in its railway system, particularly in high-speed rail.
- China is targeting decarbonization of the freight sector, responsible for roughly 65% of total transport emissions, by encouraging intermodal transport and transferring freight from road to rail and inland waterways (Ibold & Yun, 2021).

8.4. Aviation

- China's aviation sector is experiencing rapid recovery and expansion, with over 700 million passenger trips recorded in 2024—surpassing pre-pandemic levels—alongside record growth in cargo volumes and domestic air travel. While this growth underscores the sector's economic vitality, it also presents challenges for China's broader decarbonization goals. Efforts toward zero-emission aviation include increased investment in Sustainable Aviation Fuel (SAF), expansion of electric airport ground operations, and development of the domestically produced COMAC C919 jet (Xinhua, 2024), (China Travel News, 2025), (Airbus Aircraft, 2024), (The International Air Transport Association, n.d.).
- In September 2024, China launched a SAF program, starting with 12 flights from four airports in its initial phase, with expansion planned across 2025 (Lican, 2024).

8.5. Maritime

- China has seven out of the ten busiest container ports in the world. The port cargo throughput reached 15.69 billion tons in 2021 (Fangjun & Zhongwei, 2024).

4.2 Chile

Chile, a leader in GHG emissions reduction in South America, reversed its increasing trend with the coal phase-out plan, stabilizing and then decreasing emissions. The 2022 Climate Change Framework Law Targets Net Zero emissions by 2050 and promotes a participatory approach to climate governance. Chile presented its long-term climate strategy at COP26, aiming for 65% renewable energy by 2025 and 80% by 2030. The strategy includes reducing emissions from industry and mining by 70% and transport by 40% by 2050, with legally binding CO_2 targets. Climate governance is centralized under the Ministry of Environment, with the Climate Change Office managing international relations and regional actions coordinated through Regional Environment Secretariats.

Chile's transport sector accounts for 37% of total energy consumption and 26% of GHG emissions, primarily due to a heavy reliance on imported fossil fuels (95% of energy consumption). To address this, Chile has set precise GHG emissions targets for the transport sector and plans to ban combustion engine vehicle sales by 2035.

Key initiatives include the following: Expanding zero-emission light and medium vehicles; Renewing the public transport fleet with 100% zero-emissions vehicles by 2040; The National Electromobility Strategy (2017) aims for 40% electric passenger vehicles and 100% electrified public transport by 2050; The Energy Route 2018-2022 targets a 10-fold increase in Electric Vehicles (EVs) by 2022 from 2017 levels; EV market share has doubled in 2022 and increased 15-fold from 2017 to 2022; However, public charging infrastructure remains limited compared to the rise in EVs.

The Table 9 below summarizes the target details for different transport modes:

Table 9. Target Details for Different Transport Modes in Chile

CHILE [50]	
Transport Mode	**Target Details**
Road Transport[51]	**2030 Goals**: 40% reduction in urban vehicle emissions through Electric Vehicles (EVs) incentives and a target of 10,000 electric buses.
	2050 Goal: Nearly full electrification of the vehicle fleet, aiming for a significant share of electric and hydrogen vehicles.
Public Transport[52]	**2030 Goals**: Full electrification of the Santiago bus fleet, expansion of zero-emission fleets nationwide.
	2050 Goal: Complete transition to electric buses and other zero-emission modes for public transport.
Rail Transport[53]	**2030 Goals**: Expand electrified commuter rail systems in urban areas.

[50] Delgado, O., & Logiodice, P. (2025, March 28). Chile can help pave the way to clean transport in Latin America. Retrieved September 3, 2025, from icct: https://theicct.org/chile-can-help-pave-the-way-to-clean-transport-in-latin-america-mar25/

[51] Arze, L. F., & Poblete, A. (2018, August 2). Electric vehicle regulation and law in Chile. Retrieved March 25, 2025, from CMS: https://cms.law/en/int/expert-guides/cms-expert-guide-to-electric-vehicles/chile

[52] Leal, C. L., & Casas, J. V. (2025). Towards Decarbonising Transport Chile 2025. Agora Verkehrswende. Retrieved September 3, 2025, from https://www.agora-verkehrswende.org/fileadmin/Projekte/2025/Towards_Decarbonising_Transport_Chile_2025/130_Decarbonising_Transport_Factsheet_CHILE_EN.pdf

[53] Climate Action Tracker. (2024, October 7). Chile. Retrieved March 25, 2025, from Climate Action Tracker: https://climateactiontracker.org/countries/chile/

CHILE [50]	
	2050 Goal: Full decarbonization of rail, with electric trains running on renewable energy.
Aviation[54]	**2030 Goals**: Gradual increase in SAF for domestic flights and aims to have first large-scale sustainable aviation fuel factory.
	2050 Goal: Shift to SAF or alternative fuels, with ambitions for carbon neutrality in the aviation sector. Use the fuel made from oils, fats, and biological and municipal waste for half of its aviation needs
Maritime[55]	**2030 Goals**: Promote LNG and biofuels for shipping and electrify port operations.
	2050 Goal: Adoption of hydrogen and ammonia for zero-emission shipping and electrified port infrastructure.

Within the scope of examining the countries according to the benchmarking criteria, the information and documents of the following institutions were taken into consideration:

- The Ministry of Transport and Telecommunications (Spanish: Ministerio de Transportes y Telecomunicaciones)
- Ministry of Environment (Spanish: Ministerio de Medio Ambiente)
- Chile has formed with the support of the International Development Bank (IDB) - a public-private green finance group
- UNDP Agency

Benchmark Criteria for Chile

1. Policy and Regulatory Framework

1.1. National Targets and Strategies

- Chile is committed to achieving carbon neutrality by 2050, with an interim goal of reducing transport-related emissions by 30% by 2030 (Gobierno de Chile, 2017).
- Targets include increasing the share of electric buses to 100% in Santiago by 2040 and promoting low-carbon fuels in aviation and shipping (Mınısterıo de Transportes y Telecomunıcacıones, n.d.).

[54] Ministry of Transportation and Telecommunications, Ministry of Energy, Civil Aeronautics Board, Inter-American Development Bank, & Energy Sustainability Agency. (2024). Chile: SAF Roadmap 2050. Retrieved September 3, 2025, from https://vuelolimpio.cl/wp-content/uploads/2024/10/Chile_SAF_Roadmap_2050_.pdf

[55] Labrut, M. (2022, April 14). Chile to Create Green Shipping Corridors Network. Retrieved September 3, 2025, from Seatrade Maritime: https://www.seatrade-maritime.com/green-shipping/chile-to-create-green-shipping-corridors-network

- Chile targets 100% zero-emission sales for light- and medium-duty vehicles, urban buses, and taxis by 2035, and for heavy-duty trucks and intercity buses by 2045 (Pettigrew, 2022).

1.2. Regulatory Measures

- Chile has adopted Euro 6 standards for vehicles and is implementing stricter emissions regulations in collaboration with IMO and ICAO for maritime and aviation sectors (Ministerio de Energia Chile, n.d.).
- Chile has established mandates for the use of biofuels in transport and is scaling up green hydrogen production for export and domestic use in heavy transport (Ministerio de Energia Chile, n.d.).

1.3. Incentives

- Incentive programs provide subsidies for electric vehicles and tax benefits for infrastructure development, including EV charging stations.
- Chile invests in R&D for green hydrogen, electric battery technology, and sustainable mobility solutions through national research funds and partnerships (World Bank Group, n.d.).

2. Emissions Performance

2.1. Transport Sector Emissions

- Transport contributes 25% of Chile's total GHG emissions, with road transport being the primary source.
- Transport emissions account for approximately one-fourth of the national total, highlighting the importance of sectoral decarbonization efforts (International Energy Agency, 2024).

2.2. Emission Intensity

- Emission intensity has decreased in passenger transport due to the adoption of electric buses in major cities. Freight transport efficiency improvements are ongoing (Mınısterıo de Transportes y Telecomunıcacıones, n.d.). Here, “freight transport efficiency improvements” in Chile encompass measures that boost rail capacity, cut transit and handling times, lower energy use and emissions, and optimise asset utilisation:
    - Dedicated high-capacity corridors: The La Calera–San Pedro triple-track upgrade allows heavier, longer trains and cuts terminal dwell-times.

- Port–rail integration: Under the "Plan Nacional de Accesibilidad Ferroviaria a Puertos," direct rail links into terminals like Barrancas and the Santiago–San Antonio corridor slash drayage distances and transfer delays.
- Rolling-stock modernisation: Procurement of hybrid and electric locomotives—equipped with start-stop and regenerative-braking systems—cuts fuel consumption per ton by up to 20 %.

- CO_2 emissions per capita from transport are gradually decreasing, with urban areas leading the shift to low-carbon mobility (Ministerio de Energia Chile, n.d.).

2.3. Progress in Reducing Emissions

Transport emissions have been reduced by 8% over the past decade, driven by policies promoting electric mobility and renewable energy integration.

3. Infrastructure and Technology

3.1. Electrification

- Chile has over 1,500 public EV charging stations, with plans to expand this network to rural areas by 2030 (Ministerio de Energia Chile, n.d.).
- EVs and hybrids represent 3% of new vehicle registrations, with accelerated growth in urban areas (Mınısterıo de Transportes y Telecomunıcacıones, n.d.).

3.2. Public Transport and Modal Shifts

- Cities like Santiago and Valparaíso have extensive bus and metro systems. Expansion projects aim to increase rail connectivity by 2035 (Mınısterıo de Transportes y Telecomunıcacıones, n.d.).
- Approximately 30% of passenger trips are made using public transport, with government efforts to enhance service quality and affordability (Mınısterıo de Transportes y Telecomunıcacıones, n.d.).

3.3. Railway Decarbonization

- Around 50% of Chile's rail network is electrified, with projects underway to further increase this share by 2040 (Empresa de los Ferrocarriles del Estado, n.d.).
- The national rail operator is integrating renewable electricity, targeting 70% renewable sourcing by 2028 (Empresa de los Ferrocarriles del Estado, n.d.).

3.4. Maritime and Aviation

- Chile is investing in LNG bunkering facilities and partnerships for SAF production in collaboration with international stakeholders (Ministerio de Energia Chile, n.d.).
- Energy efficiency measures include upgrading shipping vessel designs and modernizing aircraft engines to reduce emissions (Mınısterıo de Transportes y Telecomunıcacıones, n.d.).

4. Renewable Energy Integration

4.1. Fuel Mix

- Renewable energy accounts for 10% of transport energy consumption, driven by biofuels and green hydrogen projects (Ministerio de Energia Chile, n.d.).
- Chile is a leader in green hydrogen production and biofuel usage, with projects targeting heavy-duty transport.
- Carbon intensity is declining due to increased investments in renewable energy infrastructure. Over 40% of electricity is now sourced from solar and wind (Ministerio de Energia Chile, n.d.).
- Chile has allocated $2 billion for renewable transport infrastructure, including solar EV charging stations and hydrogen refueling networks.

5. Economic and Social Factors

5.1. Affordability and Accessibility

- Public transport fares are subsidized for low-income households, with discounted passes available in major cities (Mınısterıo de Transportes y Telecomunıcacıones, n.d.).
- Government initiatives aim to expand access to low-carbon transport options in rural regions through new bus and rail services (Mınısterıo de Transportes y Telecomunıcacıones, n.d.).
- The country provides income tax deductions of up to 250,000 Chilean pesos for electric vehicles and waives import tariffs on new EVs until 2024 (González, Chilean Senate Introduces Incentives Project to Promote Electromobility, n.d.).

5.2. Job Creation

- Investments in transport decarbonization have generated thousands of new jobs in renewable energy, EV manufacturing, and infrastructure development (CDT, n.d.).

5.3. Equity and Inclusion

- Policies focus on ensuring transport equity by providing affordable access to clean mobility for underrepresented communities (Mınısterıo de Transportes y Telecomunıcacıones, n.d.).

6. International Collaboration and Financing

6.1. Participation in Global Initiative

- Chile participates in CORSIA and IMO frameworks, contributing to global carbon reduction in aviation and maritime sectors (International Civil Aviation Organization, n.d.).

6.2. Climate Finance

- Chile receives funding from multilateral institutions like the World Bank and UNFCCC for climate-related transport initiatives (World Bank Group, n.d.).
- Collaborative projects with neighboring countries focus on cross-border rail electrification and sustainable trade corridors (United Nations, n.d.).

7. Innovation and R&D

7.1. Development of New Technologies

- Chile invests in next-generation mobility technologies, including autonomous vehicles and advanced hydrogen applications (CDT, n.d.).

7.2. Patents and Innovation

- Chilean universities and startups are filing patents related to EVs, hydrogen systems, and battery storage (INAPI, n.d.).
- Pilot projects include autonomous electric buses in Santiago and hydrogen-powered freight trains in the north of Chile.

8. Performance of Key Transport Modes

8.1. Road Transport

- EVs and hybrids represent a growing share of new registrations, with urban electrification plans accelerating uptake (Mınısterıo de Transportes y Telecomunıcacıones, n.d.).
- Chile aims to phase out ICE vehicles by 2040, with intermediate targets for public and commercial fleets.

8.2. Public Transport

- Over 800 electric buses operate in Santiago, with plans to expand this fleet nationwide by 2035 (Mınısterıo de Transportes y Telecomunıcacıones, n.d.).
- Programs focus on replacing aging diesel buses and retrofitting vehicles for improved energy efficiency (Mınısterıo de Transportes y Telecomunıcacıones, n.d.).

8.3. Railways

- Chile is exploring high-speed rail connections between major cities, with feasibility studies underway (Empresa de los Ferrocarriles del Estado, n.d.).
- Investments in rail logistics and energy-efficient rolling stock aim to shift freight transport from road to rail (Mınısterıo de Transportes y Telecomunıcacıones, n.d.).
- Recent investments include a CAF-backed US $700 million program to modernize, electrify, and upgrade signalling on key sections of the state rail network between Santiago and the country’s major ports; the “Chile sobre Rieles” flagship works—such as the new Biobío River freight bridge and the partial electrification of the Rancagua–Chillán line along with expanded intermodal terminals; Empresa de los Ferrocarriles del Estado’s acquisition of over 50 hybrid and electric locomotives with start-stop and regenerative-braking systems (Development Bank of Latin America and the Caribbean, 2025), (Wikipedia, 2025).

8.4. Aviation

- Partnerships with international airlines support the adoption of SAF, with pilot projects targeting 10% SAF use by 2030 (Ministerio de Energia Chile, n.d.).

  Advanced air traffic systems are being implemented to reduce delays and optimize fuel consumption (Mınısterıo de Transportes y Telecomunıcacıones, n.d.).

8.5. Maritime

- Chile is fully compliant with IMO carbon intensity regulations, adopting cleaner technologies for maritime transport (International Maritime Organization, n.d.).
- LNG and hydrogen propulsion systems are being piloted in Chile's largest ports (Mınısterıo de Transportes y Telecomunıcacıones, n.d.).

4.3 Mexico

Mexico aims for Net Zero emissions by 2050, supported by a solid regulatory framework and strategic initiatives. The 2012 General Law on Climate Change mandates reporting for facilities emitting over 25,000 tons of CO_2 annually. Updated NDCs target a 22% reduction in greenhouse gas emissions and a 51% reduction in black carbon by 2030, with conditional goals of 36% and 70% reductions, respectively, dependent on international support. Black carbon is produced during the partial combustion of fossil fuels, biofuels and biomass. The black carbon particles formed during this process – invisible to the naked eye – are smaller than 2.5 microns (PM2.5) in diameter.

Mexico's transport sector initiatives to achieve Net Zero are part of a broader climate strategy. Though lacking a specific Net Zero target, Mexico's comprehensive framework, including the General Law on Climate Change, guides sustainability efforts. This framework mandates emissions reporting and verification, with updated NDCs aiming for a 22% reduction in greenhouse gases and a 51% reduction in black carbon by 2030. Further reductions depend on international support.

In Mexico's transport sector, private organizations are promoting electric, hybrid, and biomass-driven vehicles and improving vehicle efficiency. However, challenges include the lack of a combustion engine ban, low electric vehicle uptake, and insufficient charging infrastructure. To achieve Net Zero, strategic decision-making, increased financing, stronger collaboration, and support for renewable energy and carbon capture projects are needed.

The Table 10 below summarizes the target details for different transport modes:

Table 10. Target Details for Different Transport Modes in Mexico

MEXICO [56] [57]	
Transport Mode	**Target Details**
	2030 Goals: Reduce transport emissions by 22% through gradual Electric Vehicles (EVs) adoption and efficiency measures.

[56] Ruiz, A., Olea, F., Montalvo, A. F., & García, E. (2023). A pathway for a green transition of the transport sector in Mexico. WRI Mexico.

[57] Khan, T., Jimenez, C., Pineda, L., Yang, Z., Miller, J., & Sen, A. (2025, January 15). CO2 Emission Standards to Achieve Mexico’s 2030 Electrification Target for Light-Duty Vehicles. Retrieved September 3, 2025, from icct: https://theicct.org/publication/co2-emission-standards-to-achieve-mexicos-2030-electrification-target-for-ldvs-jan25/

MEXICO [56] [57]	
Road Transport[58]	**2050 Goal**: Larger-scale EV adoption and development of charging infrastructure to achieve a nearly net-zero fleet.
Public Transport[59]	**2030 Goals**: Expand urban electric bus fleets, especially in Mexico City.
	2050 Goal: Fully decarbonize public transport in urban centers through expanded electric and biofuel-powered fleets.
Rail Transport[60]	**2030 Goals**: Increase investment in rail for freight transport to reduce truck reliance.
	2050 Goal: Electrify key rail segments and expand use of renewable energy for rail operations.
Aviation[61]	**2030 Goals**: Begin SAF adoption and efficiency improvements in flight operations.
	2050 Goal: Increased SAF usage and exploration of carbon offsetting to move towards net-zero aviation.
Maritime[62]	**2030 Goals**: Efficiency improvements and increased port electrification.
	2050 Goal: Gradual transition to biofuels and green fuels, supported by electric port infrastructure.

Within the scope of examining the countries according to the benchmarking criteria, the information and documents of the following institutions were taken into consideration:

- The Secretariat of Infrastructure, Communications and Transportation (in Spanish: Secretaría de Infraestructura, Comunicaciones y Transportes, SICT) of Mexico,

[58] Khan, T., Jimenez, C., Pineda, L., Yang, Z., Miller, J., & Sen, A. (2025, January 15). CO2 Emission Standards to Achieve Mexico’s 2030 Electrification Target for Light-Duty Vehicles. Retrieved September 3, 2025, from icct: https://theicct.org/publication/co2-emission-standards-to-achieve-mexicos-2030-electrification-target-for-ldvs-jan25/

[59] Miaja, G. G., Acevedo, H., Jiménez, C., Pineda, L., & Delgado, O. (2023). Analysis of Electric Bus Performance Monitoring in Mexico City. Retrieved September 3, 2025, from https://theicct.org/wp-content/uploads/2023/01/E-bus_monitoring_Mexico_ZEBRA_dec22.pdf

[60] Alarcón, A. (2025, June 27). Mexico Business News. Retrieved September 3, 2025, from Rail Expansion, Cross-Border Growth, Green Mobility Advances: https://mexicobusiness.news/mobility/news/rail-expansion-cross-border-growth-green-mobility-advances

[61] The International Air Transport Association. (n.d.). Developing Sustainable Aviation Fuel (SAF). Retrieved June 13, 2025, from The International Air Transport Association: https://www.iata.org/en/programs/sustainability/sustainable-aviation-fuels/

[62] Safety 4 See. (2025, May 28). Mexico prepares Action Plan for maritime decarbonization. Retrieved June 13, 2025, from Safety 4 See: https://safety4sea.com/mexico-prepares-action-plan-for-maritime-decarbonization/

- The Secretariat of Environment and Natural Resources (in Spanish: Secretaría del Medio Ambiente y Recursos Naturales, SEMARNAT UNDP Agency).

Benchmark Criteria for Mexico

1. Policy and Regulatory Framework

1.1. National Targets and Strategies

- As of now, Mexico does not have an official net-zero target. In its 2016 "Climate Change Mid-Century Strategy," Mexico aimed to reduce greenhouse gas emissions by 50% below 2000 levels by 2050. However, this strategy has not been updated to align with a net-zero emissions goal by mid-century. The Climate Action Tracker currently rates Mexico's efforts as "Critically insufficient," indicating that the country's policies are not aligned with the global objective of limiting warming to 1.5°C (Climate Action Tracker, 2022).
- **Aviation:** Mexico participates in CORSIA and has implemented measures to improve fuel efficiency and promote the use of sustainable aviation fuels. The country aims to align its aviation sector with international decarbonization efforts, though specific national targets are not detailed.
- **Maritime:** Mexico supports the IMO's emission reduction strategy and is exploring the use of alternative fuels and energy-efficient technologies in its shipping industry. Specific national targets for maritime decarbonization are not specified.
- **Road Transport:** Mexico's climate strategy includes increasing the adoption of low-emission vehicles and improving fuel efficiency standards. However, detailed sector-specific targets for road transport decarbonization are not explicitly outlined.
- **Public Transport and Railways:** Mexico is investing in public transportation infrastructure, including the expansion of metro and bus rapid transit systems, to reduce urban traffic congestion and emissions. The country is also working on modernizing its railway network to promote freight and passenger rail transport as a more sustainable alternative to road transport (MBN, 2024).
- At COP 29, Mexico introduced the Zero Emission Vehicles Emerging Markets Initiative (ZEV-EM-I) to speed up the electrification of passenger vehicles, last-mile deliveries, and long-haul fleets (MBN, 2024), (World Business Council for Sustainable Development, 2024).
- The country aims for 50% of vehicles produced in Mexico to be zero-emission by 2030, and 50% of light-duty vehicle sales to be ZEVs by 2030 (Accelerating to Zero Coalition, n.d.)

1.2. Regulatory Measures

- **Vehicles:** Mexico has adopted emission standards equivalent to both U.S. and European regulations. For heavy-duty vehicles, NOM-044-SEMARNAT-2017 mandates compliance with either EPA 2010 or Euro VI standards, effective from January 1, 2021. This regulation aims to reduce emissions of NO_x, PM, and other pollutants from diesel engines.
- **Vessels:** Mexico has been working towards ratifying MARPOL Annex VI and establishing an Emission Control Area (ECA) to regulate emissions from ships operating in its coastal waters. Collaborative efforts with the U.S. Environmental Protection Agency have focused on reducing air pollution from marine vessels near coastal communities.
- **Aircraft:** Mexico adheres to ICAO's emission standards for aircraft engines, implementing regulations that align with international guidelines to control emissions of NO_x, HC, CO, and particulate matter from aviation sources (International Energy Agency, 2023).
- **Biofuels:** Mexico has implemented policies to promote the use of biofuels in transportation. The Law for the Development of Renewable Energy and Energy Transition Financing (LAERFTE), enacted in 2008, establishes frameworks to increase the share of renewable energy, including biofuels, in the national energy mix.
- **Electrification:** The state of Querétaro has adopted regulations to promote the use of renewable energy and electric vehicles (EVs) among taxi owners. As an initial step, 45% of taxis in Querétaro City are to be powered by natural gas instead of gasoline, with plans for all taxis in the greater metropolitan area to run on renewables within 5–6 years. From 2020 onwards, new taxi concessions and licenses are granted only to EVs (Norton Rose Fulbright, 2016).

1.3. Incentives

- **Electric Vehicles (EVs):** Mexico provides tax incentives for EV adoption, including exemptions from the new vehicle acquisition tax and reductions in annual circulation taxes in certain states. Some regions also offer incentives such as waivers on verification requirements and access to restricted traffic zones for EVs.
- Mexico provides income tax deductions of up to 250,000 pesos for electric vehicles, whereas conventional vehicles qualify for up to 175,000 pesos (Mobility Portal, 2024).
- **Renewable Energy Projects:** The Mexican government has implemented policies to encourage renewable energy projects, which can support low-carbon technologies across various sectors. These policies include power purchase agreements and incentives for private investment in renewable energy infrastructure (Johnson, Alatorre, Romo, & Liu, 2009).

- Mexico is also a member of the Clean Energy Ministerial, engaging in global efforts to promote clean energy technologies. Through this platform, Mexico collaborates with other member countries to share best practices and develop innovative solutions for sustainable transport (The Organisation for Economic Co-operation and Development, n.d.).

2. Emissions Performance

2.1. Transport Sector Emissions

- Mexico's transport emissions are significant, particularly from road transport, which is prevalent across the country. Efforts to mitigate these emissions include the adoption of cleaner vehicle technologies and the expansion of sustainable public transit options (World Bank Group, 2023).
- Specific data detailing the transport sector's share of national GHG emissions in Mexico is not readily available in the provided sources. However, globally, the transport sector contributes about 15% of total GHG emissions. Given Mexico's economic structure and reliance on road transport, it is plausible that the transport sector's share is comparable to or slightly above the global average (Jaramillo, Ribeiro, Newman, & Dhar, 2022).
- Mexico has pledged to cut its greenhouse gas emissions by 35% by 2030, an increase from the earlier target of 22% (Accelerating to Zero Coalition, 2022).

2.2. Emission Intensity

- Mexico's transport sector has shown increasing emission intensity over the past decades. The growth rate of transport emissions is projected to increase from 1.8% per year in the 2020-2030 period to 2.4% per year in the 2030-2050 period. Under a business-as-usual scenario, transport emissions are expected to rise from 166 million tons CO_2e in 2017 to 317 million tons by 2050 (Ruiz, Olea, Montalvo, & García, 2023).

2.3. Progress in Reducing Emissions

- Mexico's per-capita CO_2 emissions are influenced by its reliance on carbon-intensive transportation modes, such as driving and flying. Economic development and the structure of the energy system play significant roles in shaping these emissions (International Energy Agency, n.d.).

3. Infrastructure and Technology

3.1. Electrification

- Specific data on the per capita or per square kilometer availability of EV charging stations in Mexico is limited. The country is in the early stages of developing its EV infrastructure, with efforts concentrated in major urban areas. The adoption of electric vehicles in Mexico is gradually increasing, prompting initiatives to expand the charging network to support future growth (International Energy Agency, 2024).

3.2. Public Transport and Modal Shifts

- In Mexico City, public transportation is the primary mode of commuting, with 71% of journeys to work conducted via public transit as of 2019.
- Efforts to promote active transportation have led to significant increases in cycling. The introduction of new infrastructure, such as dedicated cycle lanes, resulted in a 132% rise in cycle use in Mexico City (International Energy Agency, 2020).
- BRT System: Mexico City operates the Metrobús system, which spans approximately 140 kilometers across seven lines. This system utilizes around 490 buses and serves about 1.5 million passengers daily. The implementation of Metrobús has led to a 50% reduction in travel time and a significant decrease in CO_2 emissions (Volvo Buses United Arab Emirates, n.d.).
- Comprehensive data on the share of public transport in total passenger-kilometers for Mexico is not readily available. However, in Mexico City, public transportation is the primary mode of commuting, with 71% of journeys to work conducted via public transit as of 2019. This indicates a significant reliance on public transport in urban areas (World Bank Group, n.d.).

3.3. Railway Decarbonization

- Mexico has plans to increase rail's share in land freight activity from 26.4% in 2021 to 40% within the next 50 years (SLOCAT, 2020). This shift towards rail transport is part of the country's efforts to reduce emissions from the transport sector.

3.4. Maritime and Aviation

- In the aviation sector, Mexican airlines are collaborating with international partners to promote the development and use of Sustainable Aviation Fuel (SAF). For instance, Airbus and Volaris have signed an agreement to support the International Civil Aviation

Organization's (ICAO) SAF feasibility study in Mexico, aiming to establish the necessary conditions for SAF deployment in the country (MBN Staff, 2025).

- In the maritime sector, Mexico has initiated the development of a National Action Plan (NAP) for maritime decarbonization, in collaboration with the International Maritime Organization's (IMO) GreenVoyage2050 Programme. This plan focuses on adopting cleaner fuels, upgrading port infrastructure, enhancing regulatory coordination, and investing in innovation and workforce development (Safety 4 See, 2025), (Prevljak, 2025).

4. Renewable Energy Integration

4.1. Fuel Mix

- Mexico aims to increase the share of renewable energy in its transport sector. Under current policies, the renewable energy share in transport is expected to rise from 0.8% in 2010 to 2.4% by 2030. With the introduction of about six billion liters of liquid biofuels, this could increase to 4.2% by 2030 (The International Renewable Energy Agency, 2015).

5. Economic and Social Factors

5.1. Affordability and Accessibility

- Mexico is advancing the affordability and accessibility of zero-emission transport through initiatives like the Ie-Tram Yucatán, which offers electric bus services with low fares and free access for people with disabilities. In Mexico City, the Integrated Mobility Card enables affordable travel across electric buses and bike-sharing systems, with discounts for students and seniors. Nationally, the "Olinia" project aims to provide low-cost electric vehicles for low-income families, while the ZEBRA partnership supports the rollout of electric buses in major cities (Wikipedia, 2024), (Wikipedia, 2025), (Financial Times, 2025), (Just Stories, n.d.).

5.2. Job Creation

- Mexico’s push toward net-zero emissions in the transport sector is generating significant job opportunities across electric vehicle (EV) manufacturing, infrastructure development, logistics, and clean fuel production. As a major truck producer, Mexico is targeting 36% zero-emission medium- and heavy-duty vehicle sales by 2030, with projections of over 17,000 EVs in demand by then—stimulating employment in vehicle assembly, battery production, and charging networks. Urban initiatives like Mexico City’s Laneshift are also creating green jobs in freight electrification, while the country’s potential as a hub for zero-carbon shipping fuels is driving workforce reskilling and new employment in sustainable logistics and maritime energy (Global Drive to Zero, 2023), (World Business Council for Sustainable Development, 2024), (King, 2024), (Christiansen & Ennison, 2022).

- The state of Nuevo León provides payroll tax incentives of up to 95% for OEMs investing in the electromobility sector (González, Mexico: Approval of Key Incentives to Boost Electromobility, n.d.).

5.3. Equity and Inclusion

- Mexico is integrating equity and inclusion into its net-zero transport strategy by expanding access to sustainable mobility for underserved populations. Projects like the electric Ie-Tram Yucatán offer free or discounted fares for people with disabilities, students, and seniors, while Mexico City's “Muévete en Bici” program creates safe, car-free zones to promote walking and cycling for all. Additionally, the Laneshift initiative supports small logistics providers in transitioning to cleaner freight solutions through financial assistance. These efforts aim to ensure that climate-friendly transport options are inclusive, accessible, and beneficial to all segments of society
  Mexico is integrating equity and inclusion into its net-zero transport strategy by expanding access to sustainable mobility for underserved populations. Projects like the electric Ie-Tram Yucatán offer free or discounted fares for people with disabilities, students, and seniors, while Mexico City's “Muévete en Bici” program creates safe, car-free zones to promote walking and cycling for all. Additionally, the Laneshift initiative supports small logistics providers in transitioning to cleaner freight solutions through financial assistance. These efforts aim to ensure that climate-friendly transport options are inclusive, accessible, and beneficial to all segments of society (Wikipedia, 2024), (King, 2024).

6. International Collaboration and Financing

6.1. Participation in Global Initiatives

- Mexico is participating in international efforts to decarbonize its transport sector. For example, on February 8, 2023, the University of California Alianza MX and the Mexican Ministry of Foreign Affairs launched a U.S.-Mexico Transportation Electrification Taskforce to develop a binational roadmap for the electrical transition in the automotive sector (International Trade Administration, 2023).

6.2. Climate Finance

- Mexico is advancing climate finance initiatives to support its net-zero transport goals through a mix of international funding, green bonds, and public-private partnerships. Key efforts include the E-Motion project, backed by the Green Climate Fund, which de-risks investment in electric mobility, and Inter-American Development Bank (IDB)-funded studies to modernize public transit in the State of Mexico. The country has also issued over USD 3 billion in green and sustainability bonds, including a €750 million SDG-linked sovereign bond to fund low-carbon transport infrastructure (Green Climate, 2024), (MBN Staff, 2024), (Climate Bonds, 2021).

7. Innovation and R&D

7.1. Development of New Technologies

- Mexico is exploring opportunities in electromobility. The PRODESEN 2023-2037 mentions a long-term scenario to have 4.9 million electric vehicles, or 32.3% of commercialized vehicles (light, cargo, and buses) by 2036 (International Trade Administration, 2023).

7.2. Patents and Innovation

- Mexico has been strengthening its clean-tech innovation in the transport sector as part of its net-zero goal. Patent filing activity reflects this, with approximately 1,294 to 1,305 environmental technology patents granted to Mexican residents between 2012 and 2019, according to WIPO data (Becerril, 2021).
- Momentum also exists in clean equipment innovation, such as battery storage improvements and lithium-ion and liquid metal battery Technologies (Correa, 2023).

7.3. Pilot Projects

- Mexico is implementing a range of pilot projects to support its transition to net-zero transport, including the deployment of 50 electric buses on Mexico City's Metrobus Line 3 and the IE-Tram electric BRT corridor in Merida, which features solar-powered charging and aims to serve 25,000 passengers daily. Other initiatives include electric trolleybuses in Mexico City, the MoveUp electric minibus pilot in Puebla, and early-stage trials for hydrogen-powered public transport and freight in Baja California. These pilots highlight Mexico's multi-modal approach to testing and scaling low-emission transport technologies across urban and regional contexts (Wikipedia, 2024), (Obando, 2025).

8. Performance of Key Transport Modes

8.1. Road Transport

- Road transport is the largest contributor to Mexico's transport emissions. The levels of road vehicles in use in Mexico are higher than the regional levels, and the CO_2 emissions performance for passenger cars is worse compared to other countries (SLOCAT, 2020).

8.2. Public Transport

- Mexico is in the process of expanding sustainable transport policies, with the first sustainable urban mobility plans being prepared (SLOCAT, 2020).

8.3. Railways

- Mexico has plans to increase rail's share in land freight activity from 26.4% in 2021 to 40% within the next 50 years (SLOCAT, 2020).

8.4. Aviation

- Mexico's aviation sector is progressively decarbonizing by integrating Sustainable Aviation Fuel (SAF) and enhancing operational efficiency. Leading airlines like **Aeroméxico** have set a goal of utilizing 5% SAF by 2030 and up to 95% by 2050, with over 323,000 liters already consumed in 2024, and have reduced CO_2 emissions by 10% compared to 2019 through fleet upgrades and fuel efficiency measures (Goytia, 2024).

8.5. Maritime:

Mexico is laying the groundwork for decarbonizing its maritime sector by developing a comprehensive National Action Plan (NAP) under the IMO's GreenVoyage2050 initiative, aiming to set a baseline for GHG emissions and advance port electrification, cleaner fuels, regulatory coordination, and capacity building (Green Voyage 2050, 2025).

4.4 Indonesia

With its population of nearly 300 million, Indonesia is one of the biggest developing countries in the world. Like many developing countries, Indonesia's economic growth has progressed which consequently caused the enormous increase in transport demand. Efforts to prevent the extreme impact of climate change have encountered challenges in low-carbon transition in transport sector in Indonesia as the majority of vehicles today run on fossil fuel.

The main problem in Indonesian cities is that motorized vehicle sales are growing at an alarming average rate of 8.3% per month. This can be attributed to better economic conditions which lead to higher purchasing power to own a vehicle, mainly two wheelers, but with a traditional power sources. Another challenge is that many cities have a low public transport modal share (2- 5%), many of which are not mass transport, with the exception of Jakarta (10%). The transport sector is considered as one of the highest sector of CO_2 emission, contributing 27% of the total greenhouse gas (GHG). Efforts to transform road transport to be compatible with the net-zero vision is a compelling challenge and Indonesia should equip itself with strong policies to achieve the vision.

Indonesia aims to achieve Net Zero emissions by 2060 or earlier. The country's strategy includes: Renewable Energy Expansion -Targeting 23% renewable energy by 2029, with significant investments in solar, wind, hydro, and geothermal power; Energy Efficiency - Implementing energy efficiency programs and mandatory energy management standards; EVs - Promoting EV adoption and fuel economy standards; Carbon Market - Establishing a carbon market with a carbon tax on coal-fired power plants; Just Energy Transition - Focusing on equitable green jobs and community preparation; Carbon Capture and Storage (CCS): Utilizing CCS technologies.

The Table 11 below summarizes the target details for different transport modes:

Table 11. Target Details for Different Transport Modes in Indonesia

INDONESIA [63] [64]	
Transport Modes	**Target Details**
Road Transport[65]	**2030 Goals:** 29% reduction in road emissions with a focus on Electric Vehicles (EVs), supported by investment in public charging infrastructure.
	2060 Goal: Complete electrification of light vehicles.
	2030 Goals: Increase electric buses in major cities, with targeted emissions reductions.

[63] International Institute for Sustainable Development. (2025, January). Indonesia, Net Zero Transport Strategy. Retrieved March 25, 2025, from IISD: https://www.iisd.org/savi/project/indonesia-net-zero-transport/

[64] Hasjanah, K., & Simanjuntak, U. (2025, July 14). Institute for Essential Services Reform. Retrieved September 14, 2025, from Realizing a Low-Emission and Sustainable Transportation Strategy for a Progressive Indonesia by 2045: https://iesr.or.id/en/realizing-a-low-emission-and-sustainable-transportation-strategy-for-a-progressive-indonesia-by-2045/

[65] Miller, J., Syahputri, J., Hall, D., Mahalana, A., & Posada, F. (2025). Roadmap to Zero: The Pace of Indonesia's Electric Vehicle Transition. The International Council on Clean Transportation. Retrieved September 2, 2025, from https://theicct.org/wp-content/uploads/2025/02/ID-229-%E2%80%93-IDN-roadmap_working-paper_final.pdf

INDONESIA [63] [64]	
Public Transport[66]	**2060 Goal**: Achieve net-zero in public transit, primarily through full electrification.
Rail Transport[67]	**2030 Goals**: Expand electrification, particularly in urban rail.
	2060 Goal: Fully decarbonize rail operations using green energy for both passenger and freight.
Aviation[68]	**2030 Goals**: SAF and hybrid tech exploration.
	2060 Goal: SAF adoption for long-haul flights.
Maritime[69]	**2030 Goals**: Shift to LNG and electrify port infrastructure where possible.
	2060 Goal: Emphasis on low-emission tech for shipping.

These institutions collaborate to ensure a cohesive approach towards achieving Net Zero emissions in Indonesia's transport sector:

- Ministry of Environment and Forestry: Oversees climate policies, including the National Registry System for carbon trading and storage,
- Institute for Essential Services Reform (IESR): Develops roadmaps for low-emission transportation policies at both national and regional levels,
- Ministry of Transportation: Implements policies for public transport electrification and sustainable mobility,
- National Development Planning Agency (BAPPENAS): Coordinates national strategies and investments for sustainable transport and energy efficiency,
- Regional Environment Secretariats: Work with local governments to align regional actions with national climate goal,
- World Resources Institute (WRI) Indonesia.

[66] Anam, R. K. (2025, July 3). How Are Electric Buses Progressing Under Indonesia's National Electrification Commitment? Retrieved September 3, 2025, from Transport Matters: https://itdp-indonesia.org/2025/07/how-are-electric-buses-progressing-under-indonesias-national-electrification-commitment/
[67] Southeast Asia Infrastructure. (2025, August 5). Indonesia Targets USD53 Billion in Private Rail İnvestments by 2030. Retrieved September 3, 2025, from Southeast Asia Infrastructure: https://southeastasiainfra.com/indonesia-targets-usd53-billion-in-private-rail-investments-by-2030/
[68] Giam, S. (2024, September 19). Indonesia to Require SAF for Flights from 2027. Retrieved September 3, 2025, from Argus: https://www.argusmedia.com/en/news-and-insights/latest-market-news/2609725-indonesia-to-require-saf-for-flights-from-2027
[69] Seiler, A. (2023). Decarbonizing the Maritime Industry: An Opportunity to Further Indonesia's Just Energy Transition. Center for Global Development. Retrieved September 3, 2025, from https://www.cgdev.org/sites/default/files/decarbonizing-maritime-industry-opportunity-indonesia-just-energy-transition.pdf

Benchmark Criteria for Indonesia

1. Policy and Regulatory Framework

1.1. National Targets and Strategies

- Indonesia has recently accelerated its decarbonization ambitions. In November 2024, President Prabowo Subianto announced that Indonesia aims to achieve net-zero emissions before 2050, moving up its previous target by a decade. The country plans to retire all coal and fossil-fuel power plants within the next 15 years and to construct 75 gigawatts of renewable energy capacity in the same timeframe. This initiative leverages Indonesia's abundant renewable resources, particularly solar energy (Reuters, 2024).
- **Aviation:** Indonesia is committed to CORSIA and is taking steps to improve fuel efficiency and explore the use of sustainable aviation fuels within its aviation sector. Specific national targets for aviation decarbonization are not detailed.
- **Maritime:** Indonesia's maritime decarbonization efforts align with the IMO's Revised GHG Strategy (2023). Indonesia is expected to adopt energy efficiency measures, promote the use of low-carbon fuels, and implement carbon intensity indicators (CII) and energy efficiency existing ship index (EEXI) requirements for its shipping fleet. .
- **Road Transport:** Indonesia is promoting the adoption of electric vehicles and has set a target for EVs to constitute 20% of all vehicles by 2025. The government offers incentives for EV production and purchase, aiming to reduce reliance on fossil fuels and lower emissions from the transport sector.
- The country aims to have 2 million electric cars and 13 million electric motorcycles by 2030 (School Of Public Policy, 2024).
- **Public Transport and Railways:** Indonesia is investing in mass rapid transit (MRT) and light rail transit (LRT) systems in major cities to enhance public transportation and reduce traffic congestion. The expansion of these systems is part of the country's strategy to lower emissions from urban transportation (Mccartney & Parraga, 2024).

1.2. Regulatory Measures

- **Vehicles:** Indonesia has implemented Euro 2 emission standards for light-duty vehicles and Euro IV standards for heavy-duty vehicles. However, studies have indicated that real-world emissions, particularly of NO_x, remain high. Recommendations have been made for Indonesia to develop a plan to adopt Euro 6/VI emission standards to address these challenges.

- **Vessels:** Indonesia, as a member of the IMO, is subject to MARPOL Annex VI regulations governing maritime emissions. The country is working towards implementing these standards to control NO_x and SO_x emissions from ships, contributing to global efforts to reduce maritime pollution.
- **Aircraft:** Indonesia complies with ICAO's emission standards for aircraft engines, regulating emissions of NO_x, HC, CO, and smoke to mitigate the environmental impact of aviation activities (The Real Urban Emissions (TRUE) Initiative, 2022).
- **Biofuels:** Indonesia has implemented a mandatory biodiesel blending program, known as B30, which requires a 30% blend of biodiesel with conventional diesel. This initiative aims to reduce reliance on fossil fuels and support domestic palm oil production.
- **Green Hydrogen:** While Indonesia's National Energy Policy (Regulation 79/2014) sets a target of achieving a 23% share of new and renewable energy in the national energy mix by 2025, specific mandates for green hydrogen in transportation are not detailed.
- **Electrification:** Indonesia is promoting the adoption of electric vehicles (EVs) through various incentives and infrastructure development, aiming to reduce emissions in the transport sector (Climate Action Tracker, 2023).
- Indonesia has introduced Presidential Regulation No. 55/2019 (PR55/2019), outlining a roadmap for EV and battery production (School Of Public Policy, 2024).

1.3. Incentives

- **Electric Vehicles (EVs):** Indonesia is promoting EV adoption through tax incentives, including reductions in import duties and exemptions from luxury sales taxes for EVs. The government has also introduced policies to support domestic EV production and the development of charging infrastructure.
- The government provides tax reductions and subsidies to encourage EV adoption, including 5% and 10% tax incentives for electric buses with a localization rate of 20% or higher (VnExpress, 2024).
- **Carbon Credits:** Indonesia has entered the global carbon market by selling carbon credits linked to energy projects through its national stock exchange platform, IDX Carbon. This initiative aims to attract investment in low-carbon technologies and support the country's emission reduction goals (International Energy Agency, 2022).
- Indonesia participates in the Clean Energy Ministerial, collaborating with international partners to promote clean energy solutions in the transport sector. This involvement facilitates the exchange of knowledge and best practices, supporting Indonesia's efforts

to develop and implement sustainable transport technologies (The Organisation for Economic Co-operation and Development, n.d.).

2. Emissions Performance

2.1. Transport Sector Emissions

- In Indonesia, transport is a major contributor to energy-related emissions, accounting for about 5% of the country's total energy emissions. The reliance on road transport and the increasing number of vehicles contribute to this figure (World Bank Group, 2023).
- Detailed information on the transport sector's percentage of national GHG emissions in Indonesia is limited in the available sources. However, the International Energy Agency (IEA) provides data on CO_2 emissions from fuel combustion by sector for Indonesia. According to the IEA, the transport sector is a significant contributor to Indonesia's energy-related CO_2 emissions (International Energy Agency, n.d.).

2.2. Emission Intensity

- Indonesia's transport sector CO2 emissions intensity was 34.5 g CO_2 per USD in 2023, which is higher than some of its regional peers (Asian Transport Outlook, 2024). The growth rate of transport emissions is projected to increase from 1.8% per year in the 2020-2030 period to 2.4% per year in the 2030-2050 period (Bintang, 2023).

2.3. Progress in Reducing Emissions

- In Indonesia, the transport sector contributes significantly to energy-related CO_2 emissions, accounting for 22.5% of the total. This highlights the sector's substantial role in the country's overall emissions profile (International Energy Agency, n.d.).
  Indonesia is making progress in reducing transport emissions through electrification, expanded use of biofuels, and sustainable infrastructure. Key initiatives include targets for electric vehicle adoption, the nationwide rollout of B40 biodiesel starting in 2025, and the introduction of electric buses and a high-speed rail line. Urban policies like low-emission zones and fuel quality improvements further support decarbonization, aligning with Indonesia’s broader goal of net-zero emissions by 2060 (Climate Action Tracker, 2023), (Reuters, 2024), (Haq, Bush, & O'Reilly, 2012).

3. Infrastructure and Technology

3.1. Electrification

- Indonesia is also in the nascent stages of EV infrastructure development. While exact figures are scarce, the government has announced plans to install more public charging stations to encourage EV adoption. The focus is primarily on urban centers and key transportation routes to facilitate the initial rollout of electric vehicles (International Energy Agency, 2024).
- The country plans to utilize its rich nickel reserves for EV battery manufacturing, aiming for a production capacity of 140 GWh by 2030 (School Of Public Policy, 2024).

3.2. Public Transport and Modal Shifts

- Indonesia faces challenges in shifting from private vehicle use to public transportation. The country has a high reliance on motorcycles, which are prevalent due to their affordability and convenience. Efforts to promote public transportation and active modes are ongoing, but comprehensive data on modal shifts is limited (International Energy Agency, 2020).
- **BRT System**: Jakarta's TransJakarta is recognized as the world's longest BRT system, with about 251.2 kilometers of corridors connecting the Indonesian capital city (Wikipedia, 2025).

3.3. Railway Decarbonization

- Indonesia is advancing railway decarbonization through electrification, clean energy integration, and innovation. A key milestone is the Jakarta–Bandung high-speed rail, launched in 2023 as Southeast Asia’s first high-speed line, powered entirely by electricity and significantly reducing emissions compared to road travel. Similarly, the Yogyakarta–Solo commuter line has transitioned from diesel to electric multiple units (EMUs), supporting cleaner urban transit and aligning with the National Railway Master Plan 2030 (Asian Transport Outlook, 2025).
- The country is also testing battery-powered autonomous trams in Surakarta and installing solar panels along the Trans-Sumatra rail line to supply renewable energy to trains. Supported by initiatives like the UK PACT, Indonesia is planning to integrate rail with seaports for low-carbon freight solutions. These infrastructure and technology upgrades reflect Indonesia’s commitment to sustainable rail development as part of its broader net-zero target for 2060 (UK Pact, 2024).

3.4. Maritime and Aviation

- Indonesia is actively pursuing maritime decarbonization through initiatives such as the Sea Toll Program, which aims to enhance connectivity and reduce emissions across the archipelago. The country is also exploring the use of green hydrogen as a marine fuel, with state electricity company PT PLN collaborating with the Ministry of Transportation and other stakeholders to convert conventional vessels into hybrid hydrogen-battery powered ships. Furthermore, PT Pertamina International Shipping (PIS) has unveiled a roadmap to achieve net-zero emissions by 2050, focusing on cleaner fuels, green cargo, and technological upgrades (Kavitha, 2025).
- In the aviation sector, Indonesia is advancing the development of Sustainable Aviation Fuel (SAF) to reduce greenhouse gas emissions. The Indonesian Aviation Biofuels and Renewable Energy Task Force (ABRETF) was established to support the National Action Plan for reducing aviation emissions through the utilization of sustainable alternative fuels. Additionally, Pertamina's refinery unit, Kilang Pertamina Internasional, is set to produce its first certified SAF in the first quarter of 2025, utilizing used cooking oil as the raw material. These efforts align with Indonesia's commitment to the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) and the International Civil Aviation Organization's (ICAO) global push for SAF adoption (Indonesia Business Post, 2024).

4. Renewable Energy Integration

4.1. Fuel Mix

- Indonesia aims to increase the share of renewable energy in its energy mix to 70% by 2060, with the remaining 30% still coming from fossil fuels (Tanahair, 2024). In the transport sector, the share of biofuels has increased, with biodiesel blending reaching 30% in January 2020, and plans to increase it to 40%. The government also aims to reach 20% bioethanol blending by 2025 (Wikipedia, 2025).

5. Economic and Social Factors

5.1. Affordability and Accessibility

- Indonesia has implemented initiatives to enhance the affordability and accessibility of public transportation. The Transjakarta Bus Rapid Transit (BRT) system maintains a flat fare of Rp 3,500 (approximately 27 US cents) per ride, making it an affordable option for daily commuters. Additionally, the Jak Lingko program integrates various modes of public transport, including buses, commuter trains, and microbuses, under a unified payment system, simplifying access and reducing costs for users. Efforts are also underway to improve accessibility for people with disabilities, with studies highlighting the need for inclusive design in public transport systems (The Habibie Center, 2021), (Wikipedia, 2025).

5.2. Job Creation

- The transition to sustainable transportation in Indonesia is contributing to job creation. Infrastructure projects, such as the expansion of road, rail, sea, and air networks, are expected to foster economic growth and generate employment opportunities. For instance, the development of new ports is anticipated to spur growth in trade and tourism, significantly contributing to the country's overall economic progress.

5.3. Equity and Inclusion

- Indonesia is prioritizing equity and inclusion in its transport sector. Initiatives like the "Empowering Mobility: Driving Gender Equality in E-Mobility Initiatives in Indonesia" workshop series aim to address gender disparities in transportation. Moreover, the development of inclusive bus stop facilities in Jakarta, adopted at 144 Transjakarta bus stops, demonstrates efforts to cater to the needs of people with disabilities (Institute for Transportation and Development Policy, 2024).

6. International Collaboration and Financing

6.1. Participation in Global Initiatives

- Indonesia has committed to the Paris Agreement and set a target of reaching net-zero GHG emissions by 2060 or sooner (Bieker & Mera, 2023).

6.2. Climate Finance

- To meet its climate targets, Indonesia requires substantial investment. Estimates suggest that the country needs approximately USD 285 billion in climate-aligned investment to achieve its Enhanced Nationally Determined Contribution (NDC) by 2030. The government is exploring various financing mechanisms, including public-private partnerships and international support, to bridge the funding gap (Climate Policy Initiative, 2023).

7. Innovation and R&D

7.1. Development of New Technologies

- Indonesia is exploring electric vehicle (EV) adoption, with a notable increase in two-wheeler EVs (Institute for Essential Services Reform, 2022). The country is also developing waste-to-energy plants and promoting biofuel production (Wikipedia, 2025).

7.2. Patents and Innovation

- Recent reforms to Indonesia's patent law aim to align with international practices and encourage innovation. The amended law expands the scope of patentable subject matter and streamlines the application process, which could facilitate advancements in transportation technologies (Gema & Wibowo, 2024).

7.3. Pilot Projects

- Indonesia is conducting road tests for a 40% biodiesel blend (B40) prior to its implementation (Institute for Essential Services Reform, 2022).Transjakarta, Jakarta's bus rapid transit system, plans to electrify its entire fleet by 2030, aiming for 10,000 electric buses (UK PACT, n.d.).

8. Performance of Key Transport Modes

8.1. Road Transport

- Road transport is the largest contributor to Indonesia's transport emissions, accounting for 90% of the sector's emissions and 19% of economy-wide emissions in 2022 (Asian Transport Outlook, 2024).

8.2. Public Transport

- Indonesia is investing in public transport infrastructure as part of its strategy to reduce emissions and improve energy efficiency (International Institute for Sustainable Development, 2025).

8.3. Railways

- Indonesia is enhancing its railway sector to support decarbonization efforts. The National Railways Master Plan 2030 aims to increase the passenger market share to 7–9% and freight to 11–13% of all national transportation services. The plan includes expanding the railway network to 10,524 km, electrifying lines, and reducing technological dependence by promoting local manufacturing and infrastructure development (Asian Transport Outlook, 2024).

8.4. Aviation

- Indonesia is advancing the decarbonization of its aviation sector through the development and adoption of Sustainable Aviation Fuel (SAF). The Indonesian Aviation Biofuels and Renewable Energy Task Force (ABRETF) was established to support the National Action Plan for reducing aviation emissions through the utilization of sustainable alternative fuels. Additionally, Pertamina's refinery unit, Kilang Pertamina Internasional, is set to produce its first certified SAF in the first quarter of 2025, utilizing used cooking oil as the raw material (International Civil Aviation Organization, n.d.).

8.5. Maritime

- Indonesia is actively pursuing maritime decarbonization through initiatives such as the Sea Toll Program, which aims to enhance connectivity and reduce emissions across the archipelago. The country is also exploring the use of green hydrogen as a marine fuel, with state electricity company PT PLN collaborating with the Ministry of Transportation and other stakeholders to convert conventional vessels into hybrid hydrogen-battery powered ships. Furthermore, PT Pertamina International Shipping (PIS) has unveiled a roadmap to achieve net-zero emissions by 2050, focusing on cleaner fuels, green cargo, and technological upgrades (Čučuk, 2025).

5 BEST PRACTICES IN SELECTED COUNTRIES

5.1 Denmark

Denmark has implemented several best practices to achieve net zero emissions in the transport sector:

- **Ambitious EV Adoption:** The country aims to have 500,000 plug-in electric vehicles (BEVs and plug-in hybrids) by 2030, with a goal to phase out the sale of new fossil fuel vehicles by 2030 (Haustein, Jensen, & Cherchi, 2021).

- **Tax Incentives:** Denmark offers significant tax benefits for electric vehicles, including a reduced registration tax for low- and zero-emission cars. BEVs receive a 60% discount on registration tax, while PHEVs receive a 35-50% discount (European Commission, 2025).

- **Charging Infrastructure:** The government has allocated DKK 92.5 million from 2023 to 2025 for co-financing charging stations in housing associations. Denmark also mandates that all new buildings and parking spaces support EV charging infrastructure (Kadiri, Denmark's EV Revolution: Tax Benefits and Infrastructure Boost, n.d.).

- **Workplace Charging:** From 2023 to 2026, Denmark offers a tax exemption for employer-paid electricity used for charging at the workplace, encouraging companies to provide tax-free charging facilities for employee's private EVs (Kadiri, Denmark's EV Revolution: Tax Benefits and Infrastructure Boost, n.d.).

- **Public Fleet Electrification:** The Danish government has committed to converting its entire public fleet to EVs by 2025 (Naeem, 2023).

- **Sustainable Aviation:** Denmark aims to have its first 100% sustainable domestic flight route by 2025 and make all domestic flights fossil-fuel-free by 2030. The government has allocated 1.8 billion DKK to increase demand for sustainable aviation fuels (Ministry of Foreign Affairs of Denmark, n.d.).

- **Research and Development:** Denmark has established a knowledge center for charging infrastructure with an allocation of DKK 6 million from 2023 to 2025 (Kadiri, Denmark's EV Revolution: Tax Benefits and Infrastructure Boost, n.d.).

- **Road Pricing Trials**: The country has designated DKK 1.5 million in 2023 for the development of road pricing trials for passenger cars (Kadiri, Denmark's EV Revolution: Tax Benefits and Infrastructure Boost, n.d.).

- **Sustainable Fuel Production:** Denmark is investing in Power-to-X (PtX) initiatives, such as Fjord PtX, to produce synthetic Sustainable Aviation Fuel (eSAF) (AvionTourism, 2024). Power-to-X (PtX) is an umbrella term for technologies that convert electricity—typically from renewable sources like wind or solar—into other forms of energy carriers or products, such as hydrogen, synthetic fuels, or chemicals. The "X" stands for various possible end-products like: Hydrogen (Power-to-Hydrogen), Synthetic fuels like e-methanol or eSAF (electrofuels), Methane (Power-to-Methane), Ammonia, chemicals, or even heat.

- **Public-Private Partnerships:** Denmark is fostering collaboration between key stakeholders like SAS, Copenhagen Infrastructure Partners, and major airports to drive sustainable aviation transformation (AvionTourism, 2024).

These best practices demonstrate Denmark's comprehensive approach to achieving net zero emissions in the transport sector, covering various modes of transportation and utilizing multiple strategies to drive the transition towards a sustainable transport system.

5.2 Germany

Germany has implemented several best practices to achieve net zero emissions in the transport sector:

- **Ambitious EV Adoption Targets:** The government aims to have 15 million electric vehicles on German roads by 2030, although this target may be challenging to meet As of 2025, Germany had approximately 2.59 million EVs. To meet the 15 million targets, the country would need to add over 12 million EVs in the next five years, requiring a substantial acceleration in adoption rates.

- **Purchase Incentives:** Germany offers grants of up to €40,000 for zero-emission trucks, covering up to 80% of the additional investment costs with a total funding volume of €1.16 billion until 2023 (Transport & Environment, 2021).

- **Road Charging Reforms:** The country plans to implement a CO_2-based infrastructure charge from 2023, with exemptions for zero-emission vehicles until 2025 and reduced rates thereafter (Transport & Environment, 2021).

- **Sustainable Aviation:** Germany is working towards climate-neutral flying, focusing on developing sustainable aviation fuels (SAF) and optimizing flight routes to reduce emissions (Press Division, 2024).

- **Renewable Energy Expansion:** The country is accelerating the expansion of renewable energy capacity to support the electrification of transport (McKinsey & Company, 2021).

- **Cleantech Infrastructure:** Germany is building up enablers such as hydrogen production and transportation, battery plants, and charging infrastructure (McKinsey & Company, 2021).

- **Industry Collaboration:** The country is fostering cooperation between domestic and international manufacturers to accelerate EV adoption and improve competitiveness (Wehrmann , Cooperation with China needed to achieve Germany's 2030 EV target – analysis, 2024).

- **Research and Development:** Germany is investing in innovations for decarbonizing the basic materials industry and developing green materials for the manufacturing sector (McKinsey & Company, 2021).

- **Modal Shift:** The country is promoting the transition to rail for both passenger and freight transport to reduce emissions from road and air travel (McKinsey & Company, 2021).

- **Policy Framework:** Germany has implemented the Federal Climate Change Act, setting an overall GHG emission reduction target of at least 65% by 2030 against 1990 levels (Transport & Environment, 2021).

- **Aviation Initiatives:** The Aviation Initiative for Renewable Energy in Germany (AIREG) aims to replace 10% of German jet fuel demand with sustainable alternative aviation fuels by 2025 (International Civil Aviation Organization, n.d.).

- **Efficient Air Transport:** Germany is implementing new landing procedures to reduce CO_2 emissions and optimizing flight routes to minimize the impact of condensation trails (Press Division, 2024).

These best practices demonstrate Germany's multifaceted approach to achieving net zero emissions in the transport sector, covering various modes of transportation and utilizing multiple strategies to drive the transition towards a sustainable transport system.

5.3 Netherlands

The Netherlands has implemented several best practices to achieve net zero emissions in the transport sector:

- **Ambitious EV Adoption:** By 2030, all new passenger vehicles in the Netherlands must be zero-emission. The country aims to have 15 million electric vehicles on the roads by 2030 (Netherlands Enterprise Agency, 2024).

- **Extensive Charging Infrastructure:** The Netherlands has one of the densest charging networks globally, with plans to triple the number of charging points by 2025 and increase it eightfold by 2030 (Netherlands Enterprise Agency, 2024).

- **Public Transport Electrification:** Amsterdam Airport Schiphol has been using 35 electric buses since 2015, making it Europe's largest charging station for electric buses (Transport Decarbonisation Alliance, n.d.).

- **Zero-Emission Zones:** The country plans to implement zero-emission zones for urban logistics in at least 30 cities by 2025 (Wappelhorst, 2021).

- **Sustainable Aviation:** The Netherlands aims to make 14% of aviation fuel sustainable by 2030 and 100% by 2050, surpassing EU targets (Invest in Holland, 2024).

- **Green Deal Approach:** The government has developed initiatives like the Car Sharing Green Deal to promote sustainable transport solutions (Transport Decarbonisation Alliance, n.d.).
- **Tax Incentives:** The country offers tax benefits for electric vehicles and significantly higher taxes for gasoline and diesel cars (Wappelhorst, 2021).
- **Public-Private Partnerships:** The "Smart and Sustainable" action agenda, involving 20 Dutch transport organizations, aims to decrease aviation emissions to 2005 levels by 2030 (Pronk, 2015).

- **Multimodal Shift:** The Netherlands is promoting the use of international train services and other sustainable modes for short-distance travel (Pronk, 2015).

- **Zero-Emission Airports:** The country is working towards developing zero-emission airports (Pronk, 2015).

- **Sustainable Aviation Fuel Development:** There's a focus on increasing the use and production of sustainable aviation fuels (Pronk, 2015).

- **Flight Path Optimization:** The Netherlands is working on optimizing flight paths and procedures to reduce emissions (Pronk, 2015).

- **Fleet Renewal:** The country is encouraging radical fleet renewal in the aviation sector to introduce more fuel-efficient aircraft (Pronk, 2015).

These practices illustrate how Netherlands have translated its climate goals into actionable policies across different transport modes.

5.4 Spain

Spain has implemented several best practices to achieve net zero emissions in the transport sector:

- **MOVES III Program:** An €800 million initiative running until 2023 to promote electric vehicle adoption, offering grants of up to €7,000 per EV (Fernández, 2024).

- **Sustainable Aviation Fuel (SAF) Production:** Spain is positioning itself as a leading SAF producer, leveraging its abundant renewable resources and agricultural waste for feedstock (Vurdhaan, 2024).

- **Electrofuel (eSAF) Development:** The country is focusing on electrofuels, aiming for 28% eSAF usage by 2050 (Jané, 2024).

- **Biomass Utilization:** Spain is leveraging its extensive biomass industry for sustainable energy production, exemplified by projects like Ence's plants (Jané, 2024).

- **Green Hydrogen Production:** The country is investing in green hydrogen infrastructure to support sustainable transportation (Jané, 2024).

- **Public-Private Partnerships:** Spain is fostering collaboration between government and industry to accelerate sustainable aviation and energy initiatives (Vurdhaan, 2024).

- **Port Decarbonization:** The Port of Valencia has implemented a strategy to achieve zero emissions by 2030, focusing on decarbonization and digital transformation (World Ports Sustainability Program, n.d.).
- **Modal Shift:** The country is promoting the transition of freight transport from road to rail to reduce emissions (Stenning, Hartvig, & Caspani, 2021).

- **Zero-Emission Vehicle Targets:** Spain aims to phase out the sale of new fossil fuel vehicles by 2030 (McKinsey & Company, n.d.).

- **Charging Infrastructure Expansion:** The country is ahead of the EU average in terms of charging stations per EV, with 88 chargers per 1,000 EVs (McKinsey & Company, n.d.).

- **Tax Incentives:** Spain offers a 15% deduction on the purchase of electric vehicles, extended until December 31, 2025 (Fernández, 2024).

- **Research and Development:** The country is investing in innovations for decarbonizing the transport sector and developing green materials (Vurdhaan, 2024).

Spain's efforts reflect a comprehensive and multi-pronged strategy to achieve net-zero emissions in the transport sector, encompassing diverse modes of transport and combining policy, technology, and infrastructure initiatives to accelerate the transition toward a more sustainable and low-carbon mobility system.

5.5 China

China has implemented several best practices to achieve net zero emissions in the transport sector:

- **Electric Vehicle (EV) Adoption:** China aims to have 15 million plug-in electric vehicles by 2030, with ambitious targets for new energy vehicle (NEV) sales (Yu, 2023).

- **Tax Incentives:** The government announced a 520 billion yuan tax incentive package over four years to provide tax breaks for EVs and other environmentally friendly vehicles (Interesse G. , 2023).

- **Sustainable Aviation Fuel (SAF):** China initiated a SAF program in September 2024, involving 12 flights from four airports in its first phase, with plans to expand throughout 2025 (Lican, 2024).

- **Green Freight Initiative:** China is focusing on decarbonizing the freight sector, which accounts for about 65% of total transport emissions, by promoting intermodal transport and shifting freight from road to rail and inland waterways (Ibold & Yun, 2021).

- **Vehicle Electrification:** The country is accelerating the electrification of road freight, focusing on battery-electric propulsion and innovative solutions like catenary trucks for long-haul transport (Ibold & Yun, 2021).

- **Infrastructure Development:** China is investing in charging and battery swapping infrastructure to support EV adoption (Ibold & Yun, 2021).

- **Smart Logistics:** The country is implementing digital solutions and smart logistics to optimize freight transport efficiency (Ibold & Yun, 2021).

- **Public Transport Electrification:** Cities are investing in electric buses and other clean energy public transport options (Xue & Liu, Decarbonizing China's Road Transport Sector: Strategies Toward Carbon Neutrality, 2022).

- **Renewable Energy Integration:** China is expanding renewable energy capacity to support the electrification of transport (Ibold & Yun, 2021).

- **Research and Development:** The country is investing in innovations for decarbonizing the transport sector and developing green materials (Ibold & Yun, 2021).

- **Policy Framework:** China has set targets for carbon peaking by 2030 and carbon neutrality by 2060, which guide the transport sector's decarbonization efforts (Xue & Liu, 2022). China's 2030 targets for transport decarbonization include reducing transport sector emissions by over 10% compared to 2020 levels, achieving 40% of new vehicle sales as new energy vehicles (NEVs), and significantly expanding renewable energy capacity to over 1,200 GW (Climate Action Tracker, 2025), (Davidson, 2024), (Yin, 2023).

- **Green Airport Initiatives:** Airports are implementing measures to reduce carbon emissions, such as photovoltaic power generation projects (Xue & Liu, 2022).

These practices demonstrate China's multifaceted approach to achieving net zero emissions in the transport sector, covering various modes of transportation and utilizing multiple strategies to drive the transition towards a sustainable transport system.

5.6 Mexico

Mexico has implemented several best practices to achieve net zero emissions in the transport sector:

- **Zero-Emission Vehicles Initiative:** Mexico launched the Zero Emission Vehicles Emerging Markets Initiative (ZEV-EM-I) at COP 29, aiming to accelerate the electrification of passenger, last-mile, and long-haul fleet vehicles (MBN, 2024), (World Business Council for Sustainable Development, 2024).
- **Ambitious EV Adoption Targets:** The country aims for 50% of vehicles produced in Mexico to be zero-emission by 2030, and 50% of light-duty vehicle sales to be ZEVs by 2030 (Accelerating to Zero Coalition, n.d.).
- **Tax Incentives:** Mexico offers income tax deductions of up to 250,000 Mexican pesos for electric vehicles, compared to 175,000 for conventional vehicles (Mobility Portal, 2024)**.**
- **Import Tax Exemption:** New electric vehicles are exempt from paying import tariffs until 2024, while used EVs have reduced tariffs (Mobility Portal, 2024) (Pineda, 2022)**.**
- **Vehicle Ownership Tax Exemption:** Electric vehicles are exempt from paying vehicle ownership tax in states where such a tax exists (Mobility Portal, 2024)**.**
- **Charging Infrastructure:** Mexico has the most extensive EV charging infrastructure in Latin America, with almost 2,100 charging stations as of 2022 (Accelerating to Zero Coalition, 2022).
- **Manufacturing Incentives:** The state of Nuevo León offers payroll tax reductions of up to 95% for OEMs investing in the electromobility sector (González, Mexico: Approval of Key Incentives to Boost Electromobility, n.d.).
- **Public-Private Partnerships:** Mexico is fostering collaboration between government agencies, industry giants, and infrastructure providers to accelerate the transition to zero-emission vehicles (MBN, 2024).
- **Research and Development:** The country is investing in innovations for decarbonizing the transport sector, including electric and hybrid vehicle technologies (MBN, 2024), (World Business Council for Sustainable Development, 2024).

- **Emission Reduction Targets:** Mexico has committed to reducing its greenhouse gas emissions by 35% by 2030, up from the previously announced 22% (Accelerating to Zero Coalition, 2025).

These initiatives highlight Mexico's integrated approach to achieving net-zero emissions in the transport sector, addressing key areas such as clean vehicle production and uptake, infrastructure expansion, and the implementation of supportive regulatory and policy frameworks.

5.7 Chile

Chile has implemented several best practices to achieve net zero emissions in the transport sector:

- **Zero-Emission Vehicle Targets:** Chile aims for 100% zero-emission sales of light- and medium-duty vehicles, urban buses, and taxis by 2035, and 100% zero-emission sales of heavy-duty trucks and intercity buses by 2045 (Pettigrew, 2022).

- **Energy Efficiency Law:** Chile has enacted an energy efficiency law that covers light-, medium-, and heavy-duty vehicles, setting a precedent for Latin America (Pettigrew, 2022).

- **Tax Incentives:** The country offers income tax deductions of up to 250,000 Chilean pesos for electric vehicles and exempts new EVs from import tariffs until 2024 (González, n.d.).

- **Vehicle Ownership Tax Exemption:** Electric vehicles are exempt from paying vehicle ownership tax in states where such a tax exists (González, n.d.).

- **Charging Infrastructure:** As of early 2024, Chile had approximately 920 public electric vehicle (EV) charging stations, with over 75% concentrated in the Metropolitan Region, particularly Santiago. Efforts are ongoing to improve the distribution and availability of charging stations, aiming to support the growing adoption of electric vehicles throughout the country (Mobility Portal, 2025).
- **Public Transport Electrification:** The country is incorporating electric buses into its public transport system, with plans to have 100% zero-emission urban public transport by 2035 (Pettigrew, 2022).

- **Sustainable Aviation Fuel (SAF):** Chile aims to start producing SAF in a large plant by 2030 and use SAF for 50% of its aviation needs by 2050 (Advanced Biofuels USA, 2024).

- **Research and Development:** The country is investing in innovations for decarbonizing the transport sector, including efforts to produce its first liter of SAF (Advanced Biofuels USA, 2024).

- **Policy Framework:** Chile has implemented the National Energy 2050 Policy, which establishes guidelines for improving vehicle energy efficiency (Arze & Poblete, 2018).

- **Emission Reduction Targets:** The country has committed to reducing its greenhouse gas emissions by 30% below its 2007 levels by 2030 (Arze & Poblete, 2018).

- **Public-Private Partnerships:** Chile is fostering collaboration between public and private sectors through initiatives like the "Clean Flight" project to accelerate the transition to sustainable transportation (Advanced Biofuels USA, 2024).

These measures reflect Chile's holistic strategy for advancing toward net-zero emissions in the transport sector, involving a range of transport modes and leveraging diverse policy, technological, and infrastructure solutions to foster a more sustainable mobility system.

5.8 Indonesia

Indonesia has implemented several best practices to achieve net zero emissions in the transport sector:

- **Electric Vehicle (EV) Adoption:** Indonesia aims to have 2 million electric cars and 13 million electric motorcycles by 2030 (School Of Public Policy, 2024).

- **Public Transport Electrification:** Transjakarta, Jakarta's rapid bus transit system, has committed to electrifying its entire fleet by 2030, targeting 10,000 e-buses (UK PACT, n.d.).

- **Tax Incentives:** The government offers tax cuts and subsidies to stimulate EV adoption, including tax incentives of 5% and 10% for electric buses with a localization rate of 20% and above (VnExpress, 2024).

- **Regulatory Framework:** Indonesia has introduced Presidential Regulation No. 55/2019 (PR55/2019), outlining a roadmap for EV and battery production (School Of Public Policy, 2024).

- **Battery Production:** The country aims to leverage its abundant nickel reserves for EV battery production, targeting 140 GWh of production capacity by 2030 (School Of Public Policy, 2024).

- **Renewable Energy Integration:** Indonesia is focusing on decarbonizing the energy supply to support transport electrification (International Institute for Sustainable Development, 2025).

- **Public-Private Partnerships:** The country is fostering collaboration between public and private sectors to accelerate the transition to sustainable transportation (International Institute for Sustainable Development, 2025).

- **Research and Development:** Indonesia is investing in innovations for decarbonizing the transport sector and developing green materials (International Institute for Sustainable Development, 2025).

- **Emission Reduction Targets:** The country has committed to achieving net-zero emissions by 2060 or sooner (Miller, Syahputri, Hall, Mahalana, & Posada, 2025).

- **Alternative Financing Schemes:** Indonesia is developing alternative financing schemes and business models to accelerate the acquisition of e-bus fleets (UK PACT, n.d.).

- **Infrastructure Development:** The country is working on expanding its charging network to support EV adoption (School Of Public Policy, 2024).

- **Policy Framework:** Indonesia has implemented the National Energy 2050 Policy, which establishes guidelines for improving vehicle energy efficiency (International Institute for Sustainable Development, 2024).

These efforts illustrate Indonesia's broad-based approach to reaching net-zero emissions in the transport sector, addressing multiple transport modes and employing a combination of policies, technologies, and infrastructure initiatives to support the shift toward a more sustainable and low-emission mobility system.

6 BENCHMARKING ANALYSIS

6.1 Anticipated and Achieved Results

The anticipated and achieved results of the Net Zero goals in the transport sector for the benchmarked countries have been evaluated. The alignment between strategic targets and actual developments is summarized below:

- **Denmark**: Aimed for a 70% emission reduction by 2030 and has achieved a 40% reduction in the transport sector by 2024. Incentives for electric vehicles and renewable energy integration have been successful.
- **Germany**: Targeting a 65% emission reduction by 2030, but the expected decrease in the transport sector has not yet been fully realized. While EV infrastructure has expanded, the slowdown in EV sales has hindered progress.
- **Netherlands**: Aiming for all new vehicles to be zero-emission by 2030, but EV sales have remained at around 15%. Public transport electrification has progressed successfully.
- **Spain**: Set a goal of 5.5 million electric vehicles by 2030, but as of 2024, only 1.2 million have been achieved. Carbon taxes and low-emission zones in cities have been effective.
- **China**: Leading the world in EV production, planning to peak transport emissions by 2030 and then decrease them. It remains the global leader in EV sales.
- **Chile, Mexico, Indonesia**: Developing countries face slower progress toward Net Zero goals due to infrastructure and financial challenges.

In conclusion, some developed countries, particularly in the EU, have made notable progress in reducing transport emissions, whereas developing countries face financial and infrastructural limitations.

6.2 Stakeholder Involvement and Participatory Decision-making

In the benchmarked countries, public-private cooperation plays a crucial role in decision-making processes.

- **Denmark & Netherlands**: Broad participation of government agencies, private sector, and NGOs in transportation policy formulation. Particularly, incentives for private sector investments in renewable energy have been a key success factor.
- **Germany**: The government collaborates with the automotive sector to implement Net Zero policies. However, public resistance to certain incentives has slowed the process.
- **Spain**: Cooperation between central government, local authorities, and public transport companies has enabled the implementation of low-emission zones in cities.
- **China**: A state-led decision-making process dominates, but significant investments from private enterprises and government incentives have accelerated the transition.

- **Chile, Mexico, Indonesia**: Stakeholder participation remains relatively limited in projects funded by international organizations.

For Türkiye, an important consideration is to enhance public-private collaboration and ensure active involvement of civil society in decision-making processes.

6.3 Critical Synthesis of Benchmarking Results

An analysis of the benchmarking results reveals that success is driven by three main factors:

1. **Policy Continuity and Strong Legal Framework**: Countries like Germany, Denmark, and the Netherlands have set long-term targets with clear roadmaps to achieve them.
2. **Infrastructure Investments**: Expansion of EV charging stations, electrification of public transport, and integration of renewable energy have significantly reduced emissions in the transport sector.
3. **Economic and Financial Incentives**: Policies such as EV subsidies, carbon taxes, and low-emission zones have had a substantial impact.

For Türkiye, the critical takeaway is to establish a long-term and sustainable policy framework for achieving Net Zero goals in the transport sector. Some of the more specific takeaways for Türkiye considering the best practices in benchmark countries are given in below Table 12.

Table 12: Key Takeaways for Türkiye

Best Practice Subject	Synthesis	Key Takeaways for Türkiye
Electric Vehicle (EV) Adoption and Incentives	**Denmark, Germany, Netherlands, Spain, China, Mexico**: These countries have set ambitious EV adoption targets, offering substantial tax breaks and purchase incentives for electric vehicles.	○ Strengthen tax incentives, such as reducing **Special Consumption Tax (ÖTV) on EVs** and implementing purchase grants similar to Germany's €40,000 grant for zero-emission trucks by 2053. ○ Introduce a **scrappage scheme** that incentivizes the replacement of fossil fuel vehicles with EVs by 2053.
Charging Infrastructure Development	**Denmark, Netherlands, China**: These countries have extensive and government-supported	○ **Mandatory charging infrastructure in new buildings and parking spaces** should be introduced, as seen in Denmark by 2030.

Best Practice Subject	Synthesis	Key Takeaways for Türkiye
	charging infrastructure networks.	○ Public-private partnerships should be encouraged to expand charging stations along major highways and urban areas by 2030. ○ Investments should be directed towards **battery/fuel cell swapping stations** to overcome long charging times, an approach successfully implemented in China by 2053.
Public Fleet Electrification	**Denmark, Chile, Indonesia**: Public sector fleets are mandated to transition to electric vehicles within a set timeline.	○ Municipal and state-owned fleets should phase out diesel vehicles by 2030 and transition to electric and hydrogen-powered buses. ○ Incentives for EV procurement in public transportation and postal services should be introduced. ○ Establish a national policy to ensure all newly procured government vehicles are zero-emission by 2030.
Sustainable Aviation and Green Airports	**Germany, Spain, Netherlands, China**: These countries are leading in sustainable aviation fuel (SAF) development and green airport initiatives.	○ Incentivize local production of **sustainable aviation fuels (SAF)** through R&D support and public funding. ○ Introduce **carbon reduction targets** for domestic flights, similar to Spain's goal of making 14% of aviation fuel sustainable by 2030. ○ Implement **solar panel installations at major airports**, following China's green airport strategies.
Modal Shift and Sustainable Freight Transport	**Germany, Spain, Netherlands, China**: Strong emphasis on rail and multimodal logistics to reduce	○ Develop high-speed rail and **intermodal freight terminals** to shift cargo from trucks to trains by 2030. ○ Invest in **green hydrogen infrastructure** to power long-haul

Best Practice Subject	Synthesis	Key Takeaways for Türkiye
	reliance on road transport.	freight transport, an approach seen in Spain and Germany by 2053. ○ Expand **rail electrification projects** and create incentives for logistics companies to use **low-emission transport corridors** by 2030.
Research and Development (R&D) and Innovation	**Denmark, Germany, China**: Heavy investments in EV battery technology, charging solutions, and green materials.	○ Establish a **National EV and Battery Research Center** to drive innovation by 2030. ○ Provide **tax reliefs and subsidies** for private sector R&D in battery recycling and advanced EV technologies by 2030. ○ Develop **pilot projects** for Power-to-X (PtX) solutions for green hydrogen and synthetic fuels by 2053.

6.4 Analytical Comparison of Benchmarking Countries based on the Criteria

Germany, Denmark, the Netherlands, Spain, China, Indonesia, Chile, Mexico, and Türkiye – are benchmarked on their transport sector progress toward net-zero emissions. The evaluation of the countries in terms of criteria was carried out by a large team of experts. The team of experts was selected from the public, private sector, NGOs and academia. Each of them is an expert in certain modes of transport or in the field of public transport, and they have looked at it from their own window while making their assessments. When all scores were combined, generalized results were obtained for each criterion.

6.4.1 Policy and Regulatory Framework

- **National Targets & Strategies:**

All nine countries have officially stated economy-wide climate targets, but ambition levels vary greatly. European countries lead with legally binding net-zero goals by 2050. Denmark stands out with one of the most aggressive frameworks – a *Climate Act* mandating 70% GHG reduction by 2030 vs 1990 and climate neutrality by 2050. Germany and Netherlands also score high with climate laws (Germany's enshrines net-zero 2045 and 65% cut by 2030) and detailed transport decarbonization plans aligned to EU goals. In contrast, emerging economies have weaker or non-binding targets. China has declared carbon-neutrality by 2060 (not 2050) and aims to peak transport emissions by the 2030s – a significant pledge but less stringent than Western peers. Chile recently passed a climate law targeting net-zero 2050 and set ambitious transport electrification milestones, making it a leader among developing countries. Mexico and Türkiye formally pledged net-zero (Mexico 2050 aspirational, Türkiye 2053) but lack strong transport-specific legislation or interim targets, yielding mid-range scores. Indonesia lags with only an indicative net-zero 2060 pathway and modest transport plans ("critically insufficient" ambition per independent analysis), scoring in the lower range.

- **Regulatory Measures & Incentives:**

The frontrunners pair targets with robust policies to drive action. EU-based nations benefit from EU regulations (e.g. CO_2 standards effectively banning new combustion car sales by 2035 and requiring sustainable aviation fuels) which they often augment domestically. The Netherlands for example plans 100% zero-emission new car sales by 2030 – five years ahead of the EU mandate. Denmark and Germany use hefty incentives for electric vehicles (EVs) and punitive taxes for polluters. Germany provides generous EV purchase bonuses and increased carbon pricing on transport fuels (national CO_2 levy rising to €55/ton) to spur a shift. Denmark reformed vehicle taxes to favor low-emission cars and empowers cities to set zero-emission zones. These policy tools earn high scores for European countries in this category. Developing countries are generally less advanced: Chile adopted an EV promotion law with sales mandates (all new light vehicles zero-emission by 2035) and tax incentives. China has a comprehensive regulatory toolkit – a "New Energy Vehicle" credit mandate, fuel economy standards, and subsidies totaling over $200 billion (2009–2023) – which successfully jumpstarted its EV industry. However, China's broader climate target for transport is less aggressive, moderating its score. Mexico and Indonesia have introduced some incentives (e.g. tax exemptions for EV imports, biofuel mandates) but still lack coherent, binding transport decarbonization policies. Mexico's latest climate plan only aims to cut transport emissions 18% below a growing baseline by 2030 – implying continued emissions rise rather than an absolute drop. Such limited ambition keeps their policy framework scores low. Türkiye has introduced certain measures such as reduced Special Consumption Tax (ÖTV) for electric vehicles and incentives for domestic EV production (e.g. TOGG, new BYD investment). To support domestic manufacturing, Türkiye has provided extensive incentives to companies like TOGG, including tax reductions, public financing, and investment grants, while the government's $30 billion High-Technology Investment Program targets EV, battery, and semiconductor sectors. On infrastructure, the Türkiye Government offers grants covering up to 75% of fast-charging station installation costs across all 81 provinces.However, comprehensive regulatory instruments like fuel economy standards, zero-emission vehicle sales mandates, or carbon pricing are absent. Overall, clear leaders (Denmark, Netherlands, Germany) have integrated national strategies with legal force and strong incentives, whereas laggards rely on fragmented or aspirational measures.

6.4.2 Emissions Performance

- **Transport Sector Emissions & Trends:**

High-scoring countries are those that have managed to stabilize or bend down the emissions curve, while lower performers still see rising transport CO_2. In Europe, transport emissions have barely declined from 1990 levels in countries like Germany and Denmark. Germany's transport CO_2 in 2023 was 150 Mt (21.6% of national emissions) – essentially unchanged from 1990 – underscoring past policy shortcomings. Denmark and the Netherlands similarly saw little to no net reduction in transport emissions through the 2010s, and in Denmark's case 2021 levels were *26% higher* than 1990. These countries score only mid-range on recent emissions performance despite strong current policies, because the actual reductions are still nascent. Spain's transport emissions grew with increased vehicle ownership and air travel (pre-pandemic), putting it in a similar mid-range position.

Outside Europe, the decarbonization progress is generally slower. China's transport emissions have grown explosively alongside its economic expansion – from a small share of global transport CO_2 in 1990 to the world's largest transport emitter today (roughly 900 Mt CO_2 including domestic shipping/aviation). While China's emissions intensity per vehicle is improving thanks to efficiency and EVs, absolute emissions are still rising, yielding a lower performance score for now. Indonesia and Mexico have all seen steep climbs in transport emissions (30–50%+ increases since 1990) due to rapid motorization. For example, Mexico's transport CO_2 rose 36% from 1990–2019. These countries have yet to peak their transport emissions, scoring in the bottom tier. Türkiye's transport sector emissions have steadily risen, increasing by over 50% since 1990. There has been no peaking in emissions, and current trends indicate further growth driven by increasing car ownership and freight demand. Lack of modal shift and fossil fuel dependency are key drivers. Chile is a partial exception among emerging economies – its transport emissions grew with rising car use, but recent efforts (electrifying buses, phasing out coal power) aim to flatten the curve. Chile's performance is moderate as transport CO_2 is still increasing, but at a slower rate relative to GDP.

- **Progress in Reducing Emission Intensity:**

Most countries have improved the energy or emission intensity of transport (emissions per vehicle or per km) through cleaner technology, but demand growth often outpaces these gains. In the EU, new cars are far more efficient than decades ago, yet higher travel demand and a shift to larger vehicles (SUVs) offset potential CO_2 cuts. Germany and others acknowledge that stronger modal shift (reducing car dependence) is needed in addition to cleaner vehicles. In developing countries, fuel economy standards and cleaner fuels (e.g. Mexico's shift to ultra-low sulfur diesel) have begun to curb intensity, but booming vehicle fleets still push total emissions up. One positive metric is emissions per GDP – e.g. While Türkiye has made some improvements in energy intensity due to public transport investments and a relatively clean grid (40% renewable electricity), these gains are outpaced by demand growth. EV adoption is low and modal shift is limited. Without aggressive policies, intensity advantages may soon erode. Overall, no country has achieved sustained absolute declines in transport emissions yet (aside from the temporary 2020 drop). Thus, scores for emissions outcomes are generally the weakest area across the board, with even leaders only mid-rated. Achieving steep cuts (40%+ by 2030) remains a formidable challenge ahead.

6.4.3 Infrastructure and Technology Deployment

- **Electrification of Road Transport:**

Countries differ widely in rolling out electric vehicles and supporting infrastructure. China is the clear leader in scale and speed – over 37% of China's new car sales in 2023 were electric, and it now produces more than half of the world's EVs and batteries. China scores a perfect for EV deployment, having built millions of charging points and even electrified many buses and trucks. Denmark and the Netherlands also excel – both saw *over one-third* of new cars in 2023 electrified, thanks to generous incentives and dense charging networks. The Netherlands has one of the world's densest charging infrastructures per capita and is piloting smart charging to integrate EVs with the grid. Germany is slightly behind these frontrunners in EV market share (about 18% of new cars in 2023 were full EVs), but it has set ambitious goals (15 million EVs on the road by 2030) and committed €5 billion to charging infrastructure expansion. Spain lags Northern Europe in EV uptake (10% of 2023 sales), reflecting later incentive programs and lower consumer purchasing power, though its charging network and EV sales are now growing. Among emerging economies, Chile scores relatively high due to pioneering electric buses – Santiago operates one of the largest e-bus fleets outside China and aims for 100% electric public transport by 2040. However, EV car adoption in Chile remains nascent. Mexico, Türkiye, and Indonesia are in the early stages: EVs comprise only 1–2% of new car sales in these countries. Limited charging stations and high vehicle costs are bottlenecks. Notably, Indonesia emphasizes biofuels (B35 biodiesel) more than EVs so far and is just beginning to introduce electric motorbikes and buses in Jakarta. Overall, the gulf in electrification is stark – the top countries are on track for fully electric new car fleets by 2030–2035, whereas the laggards may take much longer without increased investment.

- **Public Transport & Modal Shift:**

Infrastructure for public and active transport is another differentiator. Denmark and the Netherlands lead in cycling infrastructure and transit-oriented cities – Amsterdam and

Copenhagen have over 30–40% of trips by bicycle, enabled by extensive bike lane networks. These countries invest heavily in metros, light rail, and buses as well (Denmark's Infrastructure Plan 2035 directs DKK 86 billion to public transit and new cycling highways). Germany has expanded funding for urban public transport and introduced a nationwide low-cost transit pass (€58/month) to boost ridership, improving its score. China also shines in transit infrastructure: it has built dozens of new urban metro systems and the world's largest high-speed rail network, shifting many trips to electric trains. Chinese cities like Shenzhen achieved a 100% electric bus fleet, reducing urban emissions and air pollution. Spain has strong intercity rail (high-speed AVE network) and city metros (Madrid, Barcelona) but still relies on cars heavily outside major cities. Mexico and Indonesia have more limited transit networks – Mexico City and Jakarta have invested in BRT (bus rapid transit) and metros, but other cities remain car-centric. These gaps are reflected in lower scores for transit and modal shift in those countries. Türkiye has substantial public transport infrastructure in its major cities (Istanbul, Ankara, Izmir), including BRT systems and expanding metro lines. However, modal shift outside these areas remains limited, and investment in non-motorized transport (e.g. cycling) is minimal.

- **Railway Decarbonization:**

Shifting freight and passenger travel to rail – and electrifying rail lines – is key to net-zero transport. Europe again shows leadership: Netherlands electrified 76% of its rail network and as of 2017, 100% of its electric trains run on wind power, a model of rail decarbonization. Germany is investing €86 billion by 2030 to modernize rail and aims to electrify 75% of its network by 2030, deploying battery or hydrogen trains on the rest. Spain has electrified around 65% of its rail and continues to expand electric high-speed lines. China has electrified over 70% of its vast rail system and is aggressively building new electric rail corridors, contributing to its high infrastructure score. In contrast, Indonesia and Mexico have very limited rail infrastructure (and mostly diesel-powered), so rail plays a tiny role in mobility – a major challenge for decarbonization. Türkiye and Chile fall in between: Türkiye is expanding electrified high-speed rail between its major cities and electrifying suburban lines in Istanbul, while Chile has plans to electrify and extend its inter-city rail by 2030 (from a small base). Accelerating railway electrification is therefore a necessity for Türkiye. The completion target for critical corridors can be advanced from 2035 to 2030. Such an acceleration is essential to ensure alignment with European Union standards and to prevent the continued reliance on diesel traction and the associated emissions.

- **Maritime & Aviation:**

Cleaner technology is just emerging in these modes. Here leadership is more about future planning and pilot projects. Denmark leverages its major shipping industry – e.g. Maersk's first carbon-neutral methanol-fueled ships – and spearheads initiatives like the *Clydebank Declaration* for green shipping corridors (signed by Denmark, Germany, Netherlands, Spain, Chile and others to create zero-emission maritime routes). Germany and the Netherlands are also promoting shore-side electrification in ports and investing in hydrogen/ammonia fuel R&D for ships. In aviation, EU countries and Türkiye support the new EU mandate for Sustainable Aviation Fuel (SAF) blending – targeting *63% SAF by 2050* for flights from EU airports. Investments in LNG bunkering and green port initiatives are ongoing in Istanbul and Mersin. However, sustainable fuel adoption remains at pilot stage. Germany and Spain host pilot plants for synthetic aviation fuels, and Denmark set a bold goal for its domestic flights to be fossil-free by 2030. China is beginning to test biofuels on commercial flights and improve aircraft efficiency, but its massive aviation growth tempers progress. Indonesia and Mexico have done little in aviation or maritime decarbonization so far beyond efficiency measures; Chile has joined international pledges (like a 2045 zero-emission shipping fuel goal) but is in early stages domestically. Overall, in Infrastructure and Technology Category, the leaders score 9–10 owing to rapid EV rollout, strong transit and rail systems, and active pilot programs in hard-to-abate modes, while laggards score <5 due to slow adoption of these critical technologies.

6.4.4 Renewable Energy Integration

- **Cleaner Fuel Mix in Transport:**

Integrating renewable energy into transport fuels is crucial for net-zero. The highest scores go to countries that have increased the share of renewables (electricity or biofuels) in powering transport. European countries benefit from the EU Renewable Energy Directive, targeting >14% renewable energy in transport by 2030. Germany and Spain are on track to meet these targets via a mix of advanced biofuels (like synthetic diesel, bio-methane for trucks) and rapid electrification. Germany, for instance, plans to ramp up advanced biofuels and e-fuels to meet EU requirements, and its complete coal power phase-out by 2030 will ensure EVs are increasingly charged on green electricity. Denmark already has one of the greenest electricity supplies – over 50% from wind and solar – meaning each new EV or electric train immediately cuts emissions. Denmark also blends biofuels in road fuels and is investing heavily in Power-to-X projects (converting surplus wind power to green hydrogen and e-fuels for buses, ships, aviation). The Netherlands has become a center for biodiesel and synthetic fuel innovation (Rotterdam hosts major bio-refineries) and, like Denmark, its high renewable electricity share amplifies the impact of transport electrification.

Outside the EU, progress is mixed. Chile stands out with a rapidly decarbonizing grid – approaching 50% renewable electricity (mainly solar and wind) – and a national green hydrogen strategy. Chile's electric buses and future EVs will be running on an increasingly clean grid, giving it a high score in this category. It also exploring green hydrogen fuel for mining trucks and has attracted investment for e-fuel (synthetic gasoline) pilot plants. China has a lower current share of renewables in transport energy since its EVs still draw on a coal-heavy grid (around 30% non-fossil electricity). However, China is adding renewables at record pace and plans for 25% of total energy from non-fossil by 2030, which will steadily improve its transport fuel mix. China also pushes *bioethanol (E10)* in gasoline in some provinces and leads the world in electric two-wheelers, which use grid power. Indonesia relies heavily on fossil fuels for transport, but it has implemented one of the world's highest biodiesel blending mandates (B35). This biofuel program (using palm oil) boosts Indonesia's renewable fraction in transport energy to some extent, lifting its score. However, Indonesia's power generation is dominated by coal, so electrifying transport yields little GHG benefit until the grid is cleaner. Mexico and Türkiye score lower on fuel mix. Mexico has made only limited forays into biofuels or EVs and, alarmingly, has reversed some clean energy policies (its grid remains 75% fossil-fueled). Türkiye has a moderately high renewable electricity share (40%, thanks to hydro and wind) which will aid EV emissions, and it has small biofuel quotas, but it still leans on imported oil for transport.

- **Grid Decarbonization & Investment:**

The integration of transport with renewable energy also hinges on grid upgrades and investment in clean power. Here Denmark and Chile excel by aligning transport electrification with robust green power pipelines (e.g. Denmark's upcoming offshore wind islands, Chile's new solar farms) – ensuring EVs, trains, and future e-fuels are truly low-carbon. Germany is pouring investments into renewable projects (aiming for 80% renewable electricity by 2030) which complements its electrify-transport strategy. China leads in absolute renewable investment (hundreds of GW of wind/solar being added), but also in coal usage – a contradiction it must resolve to fully decarbonize transport. In summary, countries integrating high shares of renewables into both power grids and liquid fuels (bio/synthetic) receive top marks, while those still heavily dependent on fossil energy supply score poorly. This KPI reveals a major gap between European and Latin American climate-progressive states versus others. Türkiye has significant wind and solar energy potential and ongoing investment in renewables. In this regard, TCDD has ongoing initiatives. It is planned to establish "zero-emission railway lines" by supplying 100% of the electricity required by trains from renewable energy sources. Within this framework, a 300 MW solar power plant (SPP) investment has been made. However, the implementation of these policies requires certain regulatory and planning-related flexibilities (e.g., zoning plans). Also, transmission infrastructure upgrades and integration with transport electrification need better coordination.

6.4.5 Economic and Social Factors

- **Affordability & Accessibility:**

A just transport transition requires affordable low-carbon mobility for all. The highest performers implement policies to make clean transportation accessible across income groups. Germany and Spain have introduced discounted transit fares (Germany's €58/month pass, Spain's free short-distance rail trips scheme) to encourage usage and improve affordability. These measures, along with subsidies for EV purchases and charging infrastructure in rural areas, earn Germany a strong score on equity. Denmark and Netherlands also emphasize accessible mobility – their cities are designed for walking and cycling (essentially free modes of transport), and governments invest in reliable public transit even in smaller towns. EV incentive structures in these countries are often designed to favor mass-market cars (tax breaks for cheaper EV models, for example) and used EV imports, widening access beyond the wealthy. China has made impressive strides in producing affordable EVs (some models like the Wuling Mini cost under $5,000), putting electrification within reach of lower-income consumers. It also massively expanded public transit networks – improving access to mobility for millions who cannot afford cars – and kept transit fares low in many cities. However, rural areas in China still have less access to clean transport options, and car ownership remains concentrated among higher earners.

In lower-income countries, ensuring equity is challenging. Chile has approached transport decarbonization with an eye on social benefits – Santiago's electric buses not only cut carbon and air pollution but also operate in poorer neighborhoods, improving public health. The government has worked to keep transit fares stable during the bus fleet renewal (recognizing that past fare hikes sparked unrest). Indonesia and Mexico score lower as they have yet to substantially improve clean mobility access. Much of their population relies on motorbikes or informal transport. EVs remain expensive luxury goods in these markets (though Indonesia is promoting cheaper e-motorbikes). Both countries continue to spend on fuel subsidies to keep gasoline affordable, which aids the poor in the short term but undermines long-term transition. Redirecting such funds to public transit or EV incentives for low-income drivers is a looming task. Türkiye is intermediate – it has good public transit in Istanbul and Ankara that many depend on, and its new domestic EV (TOGG) is a point of national pride, but that EV is currently a high-end SUV not accessible to average consumers. Fuel prices have risen, straining household budgets, but the government plans targeted subsidies for electric tractors and delivery vehicles to help small businesses.

- **Job Creation and Economic Opportunities:**

The transition to Net-zero transport is also an economic opportunity. China leads on job creation, with its EV and battery industry supporting millions of jobs and making the country a global export hub. This boosts China's social score – the government often highlights EV industry growth as a poverty reduction and development tool (e.g. EV factories in poorer regions). Germany and Spain are leveraging the transition to revitalize industry: German automakers are retraining workers for EV production and building battery gigafactories domestically, aiming to secure hundreds of thousands of future-proof jobs. Spain's EV push (like converting SEAT's plants to EV production and expanding wind turbine manufacturing for energy) is central to its post-pandemic recovery plan. Indonesia and Chile view climate-friendly transport as a new job sector as well:

Indonesia is attracting foreign investment for domestic battery manufacturing (leveraging its nickel resources) to create jobs and reduce vehicle import costs, while Chile's copper and lithium mining sectors stand to benefit from surging global demand for EV materials, supporting employment (though, it is essential to ensure that these mining jobs are sustainable and deliver meaningful benefits to local communities. . Türkiye's EV industry, battery production, and charging infrastructure present economic opportunities. Investments in local manufacturing and technology transfer from the EU are underway, but more coordination is needed to create large-scale employment.

- **Equity and Inclusion:**

Finally, equity considerations include geographic and demographic inclusion. Top countries ensure rural areas are not left behind (e.g. Netherlands subsidizing electric buses in provincial towns, Denmark funding charging stations in all municipalities). They also address disability access – for instance, Spain's transit expansion includes fully accessible trains/buses, and Germany is rolling out barrier-free stations. Public engagement and acceptance are also important: Denmark's climate policies enjoy broad public support, partly because the costs (like EV incentives) are transparently funded, and benefits (clean air, better mobility) are shared. In lower scoring countries, the benefits and costs of policies are unevenly distributed – e.g. fuel price increases without alternatives hit low-income drivers in Mexico, or electric buses in Jakarta serve the capital but smaller Indonesian cities still have old, polluting minibuses. These disparities underline the need for more inclusive policy design. In summary, European countries and China score highest on economic & social dimensions due to deliberate measures to make the green transport transition widely beneficial, whereas countries with less-developed social support measures score lower. Bridging this gap will be critical to sustaining public support for net-zero goals. Urban transport systems are relatively accessible, but rural regions and small towns lag in Türkiye. Disability of access is improving in new metro systems. However, targeted policies for transport equity are still evolving.

6.4.6 International Collaboration and Financing

- **Participation in Global Initiatives:**

Leading countries reinforce their domestic efforts with active international engagement on transport decarbonization. Denmark earns a top score as a "green diplomacy" champion – it was a founding signatory of the Clydebank Declaration for green shipping corridors and leads the Mission Innovation transport challenge on hard-to-abate sectors. Germany and the Netherlands also strongly participate in global alliances: both support the Transformative Urban Mobility Initiative (TUMI) aiding developing cities and are members of the ZEV Alliance pushing for all new vehicle sales to be electric by 2040. The Netherlands and Chile co-chair the Transport Decarbonisation Alliance of countries, cities, and companies sharing best practices. Chile, despite its size, punches above its weight by joining numerous pacts – at COP26 it signed a memorandum with 15 nations committing to 100% zero-emission truck and bus sales by 2045, and it was integral to launching the Green Hydrogen Americas initiative. Spain engages through the EU and bilaterally in Latin America, though it is somewhat less prominent individually. After ratifying the Paris Agreement, Türkiye has engaged in some clean energy platforms and participation in international green transport forums is growing.

- **Climate Finance and Support:**

In climate financing, wealthy nations are expected to contribute and facilitate funds for green transport in developing countries. Germany is a top contributor of international climate finance (over €5 billion annually across mitigation and adaptation programs), including funding for low-carbon transport projects abroad (such as electric bus pilots in India via its International Climate Initiative). Denmark and the Netherlands also provide high per-capita climate aid, financing renewable energy and clean mobility in Asia and Africa. This elevates their scores to the top tier. China, as a developing country, is not a donor in the traditional sense, but it plays a major role via its Belt and Road Initiative: recently China pledged to stop funding overseas coal and instead support green infrastructure. Chinese firms are financing electric railway and subway projects in countries like Egypt and Pakistan. Still, China's stance in climate negotiations is that developed nations must lead on finance, so China's score here is moderate – it collaborates on technology (exporting affordable EVs and batteries globally, which is a form of South-South support) but provides limited direct climate funding.

Recipient countries like Indonesia and Türkiye have secured large international climate finance deals tied to transport and energy. Indonesia in 2022 entered a $20 billion Just Energy Transition Partnership (JETP) with G7 nations to accelerate its power and transport decarbonization. Türkiye, upon ratifying Paris Agreement in 2021, unlocked access to climate funds and development bank loans (e.g. financing for electric buses in Istanbul from the EBRD). To support railway modernization, international development finance instruments—such as the European Bank for Reconstruction and Development (EBRD) and the Green Climate Fund (GCF)—can be utilized through partnerships similar to the examples mentioned above. These collaborations improve their scores slightly as they show willingness to engage globally. Mexico, however, has been less active on the international stage in recent years. It did join the 2021 Global Methane Pledge and coordinates with the U.S. and Canada on vehicle standards to an extent, but it has not been a leader in international transport climate initiatives and has even cut back domestic climate institutions.

In summary, Denmark, Germany, and the Netherlands rank at the top for KPI "International Collaboration and Financing", leveraging diplomacy and finance to drive global transport decarbonization (and in turn learning from others). Chile also ranks high for a developing nation.

China and the EU states are pushing multilateral efforts in aviation (through ICAO's net-zero 2050 goal) and shipping (IMO's new zero emissions by 2050 target, which all these countries support). The laggards are those either not contributing to their fair share of climate finance or not actively engaged in international partnerships to green transport. As global cooperation deepens (e.g. on setting EV standards, battery supply chains, and green corridor agreements), we can expect some of these countries to improve in this dimension.

6.4.7 Innovation and R&D

- **Development of New Technologies:**

The race to net-zero transport is spurring innovation in vehicles, fuels, and systems. China clearly leads in sheer R&D output – it accounts for 65% of high-impact research publications on EV batteries and a rapidly growing share of patents. Chinese companies have innovated in areas like ultra-fast EV charging, long-range electric trucks, and autonomous driving algorithms. This earns China a top innovation score, as it is not just adopting but also creating cutting-edge solutions (e.g. world-leading electric bus designs, and the first commercial hydrogen fuel cell trains in development). Germany remains a powerhouse of automotive R&D, now pivoting from combustion engines to electric and hydrogen technologies. German firms are world leaders in hydrogen fuel cell development for heavy vehicles and synthetic fuels for aviation, supported by government programs (the German Aerospace Center is testing pilot plants for power-to-liquid jet fuel). Germany also invests heavily in smart mobility R&D – digital rail signaling, vehicle-to-grid charging, etc.

The Netherlands fosters innovation especially in logistics and urban mobility – for instance, Dutch companies pioneered electric vehicle charging technologies and smart traffic management systems. Eindhoven is a hub for electric truck and bus development (DAF and VDL companies). Denmark focuses its transport R&D on maritime and energy integration (designing next-gen wind-powered ships, electrified ferries, and fuel efficiency in shipping known as "Blue Denmark" initiatives). Denmark is also piloting electrified road systems (testing dynamic charging coils under roads for trucks) and advanced bicycle infrastructure (like traffic management AI for bike lanes), demonstrating niche innovation leadership. Spain contributes via its rail industry (Talgo and CAF are developing hydrogen-electric hybrid trains) and is investing in drone logistics and urban air mobility prototypes in cities like Barcelona.

Among emerging economies, Türkiye and Mexico have moderate innovation activity. The market launch of Türkiye's domestically developed electric vehicle TOGG, together with the ongoing design and battery integration efforts in electric and hybrid light vehicles, buses, and trucks by various domestic firms, indicates a growing local R&D capacity. Turkish universities are researching hydrogen buses and synthetic fuels, often in collaboration with European firms.

Mexico's automotive sector is large but dominated by foreign manufacturers; however, there's growing local innovation in EV components and charging infrastructure tailored to Latin American conditions (e.g. tackling high-heat environments). Chile has become a living lab for innovative pilots – from green hydrogen in mining trucks to partnering with companies like Airbus on studying electric aircraft feasibility in the thin air of high altitudes. Chile's policy of open-data and sandbox regulations in Santiago has allowed startups to test mobility apps and electric shared scooters, etc. Indonesia currently has the least R&D in this field; most technology is imported. That said, Indonesia is investing in research on biofuels (to improve palm biodiesel sustainability and develop aviation biofuel) and seeking technology transfer through joint ventures (e.g. inviting foreign EV makers to build R&D centers locally).

- **Patents and Innovation Outputs:**

Patent statistics reflect these trends. The share of global electric vehicle propulsion patents held by Chinese entities rose to 27% in 2020 (from virtually zero a decade earlier), thereby surpassing many Western countries. Germany and Japan continue to maintain large patent portfolios in automotive engineering; however, China's rapid rise demonstrates that its innovation engine is operating at full capacity. The United States (although not included in our list) is also a major player in this field. Smaller European countries such as the Netherlands and Denmark rely more on collaborative research and niche patents (for example, Danish researchers are leaders in patents related to wind-to-hydrogen fuel technologies).

- **Pilot Projects:**

While all countries have implemented certain pilot initiatives, leading countries integrate these efforts into a broader innovation ecosystem. For instance, Germany's "living lab" initiatives test concepts such as autonomous shuttles and on-demand electric trucks in real urban environments, generating evidence to inform large-scale deployment. China is developing smart cities (e.g., Xiong'an) planned around autonomous electric vehicles and vehicle-to-grid technologies. Mexico and Indonesia have launched fewer pilot projects; nevertheless, Mexico City and Jakarta are piloting electric buses with international support.

In summary, China and Germany rank highest in the Key Performance Indicators, as both are pioneers in the development of new transport technologies (with China focusing on large-scale commercialization, and Germany emphasizing engineering excellence and quality). The Netherlands and Denmark also score highly due to their strong innovation cultures and well-developed cleantech industries. Developing countries display variation: Chile stands out for its proactive adoption of innovation, whereas Indonesia scores lower due to its continued reliance on imported technologies. It is worth noting that innovation is dynamic—countries investing today in education, research, and international partnerships (such as Türkiye's collaborations under the EU Horizon programmes) are likely to enhance their innovation performance in the coming years.

6.4.8 Performance of Key Transport Modes

Each transport mode's progress toward net-zero was evaluated, as different modes face different challenges. A summary of how countries perform in road, public transport, rail, aviation, and maritime is given below:

- **Road Transport (Passenger & Freight):**

Countries with high electric vehicle uptake and strong fuel efficiency policies score best. Norway (not in our list) sets the benchmark with nearly all new cars electric, but among the profiled countries, Denmark, Netherlands, and China lead. Denmark and the Netherlands have rapidly growing EV fleets (over a third of new cars EV) and robust policies to phase out internal combustion cars by 2030. China leads in electrifying not just cars but also two-wheelers and city buses. Germany follows closely, with a quarter of new cars electric and tightening truck emissions standards; its road transport score is high except for still-high SUV usage. Chile and Spain are making progress – Chile with electric buses and a 2035 zero-emission vehicle sales goal, Spain through EU vehicle CO_2 standards and incentives. Mexico, Indonesia, Türkiye rank low for road transport decarbonization. They still have low EV penetration and relatively lax efficiency rules. Mexico has announced an aim to phase out fossil-fuel cars by 2035, but EVs are <2% of sales today. Indonesia and Türkiye only recently introduced EV incentives; their road vehicle emissions are still rising with growing motorization.

- **Public Transport:**

The quality, electrification, and utilization of public transit systems vary widely. European countries score high thanks to extensive, low-emission transit networks. Germany, Spain, and the Netherlands have well-developed urban transit (metros, trams, BRT) and are greening bus fleets (e.g. Netherlands targets 100% zero-emission buses by 2030). Denmark's capital Copenhagen aims for 75% of trips by foot/bike/transit by 2025 and is close to 100% electric buses already. China also scores very high – its cities operate over 400,000 electric buses (more than all other countries combined) and have rapidly expanding subways, which has shifted many commuters to cleaner transport. Chile performs well in this mode too, with Santiago's massive electric bus rollout and metro expansion improving transit mode share. Türkiye's major cities have invested in subways and BRT (Istanbul has one of the world's largest BRT systems), earning it a mid-pack score. Mexico and Indonesia lag; outside of Mexico City and Jakarta, public transit is often underdeveloped, and many rely on cars or informal minibuses. Both are taking steps (new metro lines, BRT in secondary cities), but transit use and electrification remain limited. Effective modal shift to public transport is an area where Europe and China strongly outperform.

- **Railways:**

Decarbonizing rail involves both electrifying lines and shifting more travel to rail. The Netherlands is exemplary – nearly all trains are electric and run on renewable energy, and rail carries a large share of commutes. Spain and Germany also score high, due to major rail modernization programs. Spain's high-speed rail has attracted riders from aviation (Madrid-Barcelona air travel dropped significantly in favor of rail), and Germany aims to double rail ridership by 2030 through its integrated timetable and investment plan. China has the highest rail usage in absolute terms and has electrified most of its network, including freight corridors – giving it a top score for rail decarbonization. On the other hand, Indonesia and Mexico score very low since rail plays a minimal role; Indonesia has only a few urban rail lines and one intercity line in Java (mostly diesel), and Mexico until recently had almost no intercity passenger rail. Chile and Türkiye are intermediate – Chile is reviving some electric rail connections (e.g. Santiago–Chillán line by 2025) and Türkiye's intercity rail electrification is improving (Ankara-Istanbul high-speed line is electric and popular). For secondary and regional lines where electrification is difficult or costly, pilot procurements of hydrogen fuel cell or battery-electric train technologies—similar to Germany's Alstom Coradia iLint—can be undertaken, and opportunities for domestic production can be explored. By 2030, the electrification rate on main corridors with high passenger and freight traffic may be increased to over 75%. Türkiye's railway electrification target envisions the completion of near-full electrification by 2035, with an interim objective of achieving approximately 90% electrification in the medium term. However, this timeline lags behind the requirements set by the European Union's Trans-European Transport Network (TEN-T) framework, which mandates the full electrification of the core railway network by 2030. This relatively slow pace of progress risks limiting Türkiye's integration into EU-aligned railway corridors and may lead to its partial exclusion from strategically significant trans-European rail networks.

Overall, rail decarbonization is a strong point for EU countries and China, and a weak point for the others.

- **Aviation:**

All countries face difficulties reducing aviation emissions, but the EU countries are taking earlier action via policy. Germany, Denmark, Spain, Netherlands all support the EU's ReFuelEU Aviation mandate, requiring airlines to blend at least 63% sustainable aviation fuel by 2050. This gives them relatively higher scores in aviation performance, even though actual emissions from aviation are still growing. They also invest in high-speed rail to substitute short flights and are part of the UN's CORSIA program to offset aviation growth. China is now the world's largest domestic aviation market – it is improving aircraft efficiency and researching biofuels but has not yet implemented strong measures to limit aviation CO_2, resulting in a moderate score. Chile and Mexico have lower aviation volumes but also limited policies; Chile has joined the International Aviation Climate Coalition and is exploring using its biofuel feedstocks for jet fuel, giving it a slight edge over Mexico, where airline emissions are rising unchecked. Indonesia and Türkiye have rapidly growing aviation sectors (Türkiye's new Istanbul airport is a global hub). Both have signed on to ICAO's net-zero 2050 goal, but tangible actions (like incentives for SAF or managing demand) are nascent. They rank in the lower-middle for aviation. In short, no country scores extremely high here – even leaders must rely on future technology (electric or hydrogen aircraft in development) – but Europe's regulatory push and alignment on aviation climate goals put its countries a step ahead.

- **Maritime:**

In shipping, Denmark is a top performer due to its large shipping industry that is proactively decarbonizing. Danish shipping giant Maersk has ordered a fleet of carbon-neutral methanol ships and Denmark is creating green hydrogen bunkering facilities at its ports. Denmark, Chile, and others forming green corridors means by 2025 we'll see the first low-carbon shipping routes. Germany and Netherlands also score high – Germany is electrifying port operations (shore power so ships can turn off engines at berth) and experimenting with hydrogen fuel cell vessels on inland waterways. The Netherlands (with Rotterdam port) is a leader in sustainable fuels infrastructure for ships and has mandated emission control areas in its waters. Spain and Türkiye are implementing IMO rules and investing in LNG bunkering as a transition fuel but have fewer domestic industry champions in green shipping. China is the world's biggest shipping nation by volume – it's building some electric ferries and announced a goal to peak shipping emissions before 2030 but also operates many coal-fueled ships. China's maritime score is moderate since it has the capacity to innovate (e.g. launching the first electric container barges) but hasn't yet shifted most of its vast fleet to clean energy. Indonesia and Mexico trail; Indonesia relies on oil-fueled ships for its archipelago connectivity and is just starting to consider electrified ferries for short routes, while Mexico's shipping (e.g. ports of Veracruz, Manzanillo) has seen little in terms of alternative fuels or shore power adoption. Both could benefit from international aid to green their maritime sectors.

In summary, Denmark, Netherlands, Germany, and China exhibit the most balanced, high performance across all modes, while Indonesia and Mexico perform weakest across modes. Others like Spain, Chile, and Türkiye have strong points in certain modes but not all. This multi-modal perspective underscores that even top countries have room for improvement (especially in aviation), and holistic progress is needed to achieve net-zero transport by mid-century.

6.4.9 Overall Ranking and Summary

Considering all the information and findings obtained as a result of this benchmarking study, the countries were scored between 1-10 on the basis of criteria. This scoring study was carried out together with the experts in the transportation and logistics sector as well as the experts in the project team. These experts were selected to represent the air, rail, road, sea, finance, energy and local transportation sectors (11 assessing experts in total). The scoring matrices of the evaluators representing these different sectors are shared in the appendix of the report. By taking the average of all these evaluations and taking into account the findings obtained on the basis of countries and criteria in the report, the following interpretations are made.

Bringing together all KPI scores, we see a clear lead for the European countries – particularly Denmark, the Netherlands, and Germany, which rank 1st, 2nd, and 3rd overall. These three have comprehensive strategies, are cutting-edge in technology adoption, and actively address economic and international dimensions of transport decarbonization. Spain ranks 4th overall, leveraging strong EU-wide measures and consistent progress across categories to narrowly surpass China (now 5th). China's unparalleled infrastructure roll-out and innovation push remain major strengths, but its still-high emissions and moderate policy stringency have caused its overall score to fall just below Spain's. Chile ranks 6th, demonstrating climate leadership among emerging economies with ambitious targets and policies. By contrast, Türkiye, Mexico, and Indonesia round out the lower ranks (7th, 8th, and 9th respectively), reflecting that their transport sectors are still in the early stages of transition and face significant hurdles ahead. The Table 13 below summarizes the scoring (1–10 scale) for each KPI category and the overall performance ranking:

Table 13: Overall Performance Ranking

Rank	Country	Policy (A)	Emissions (B)	Infra & Tech (C)	Renewables (D)	Econ/Social (E)	Collab/Finance (F)	Innovation (G)	Modes (H)	Overall
1	**Denmark**	9,4	5,8	8,8	9,2	8,6	9,4	7,9	8,8	**8,5**
2	**Netherlands**	8,7	6,2	9,0	8,6	8,4	8,9	8,2	8,8	**8,4**
3	**Germany**	8,6	5,6	8,2	8,4	8,5	9,2	8,8	8,5	**8,2**
4	**Spain**	7,6	5,6	6,8	7,8	7,5	7,1	7,0	7,2	**7,1**
5	**China**	6,3	4,2	9,1	6,3	6,7	6,2	9,5	8,1	**7,0**
6	**Chile**	7,2	5,8	6,3	8,1	7,1	7,8	6,8	6,5	**6,9**

7	**Türkiye**	5,4	4,2	5,0	6,1	5,7	6,0	5,6	5,7	**5,5**
8	**Mexico**	4,6	3,4	3,7	3,5	4,0	4,5	4,6	4,0	**4,0**
9	**Indonesia**	3,8	2,5	3,1	4,2	4,1	5,9	3,6	3,4	**3,8**

Denmark emerges as the overall leader with a very high score (8.5/10), excelling especially in policy commitment, international collaboration, and a balanced effort across all modes. The Netherlands and Germany follow closely. Both are strong in nearly every category with only minor weaknesses – for example, Germany's lower score in the emissions category reflects its past difficulties in cutting transport emissions quickly.

Spain's performance places it 4th. This strong showing is driven by a robust policy framework (bolstered by EU climate initiatives) and steady improvements in infrastructure and clean energy uptake. Spain's balanced progress across indicators allowed it to edge ahead of China. Meanwhile, China demonstrates exceptional strengths in technology deployment and innovation – it has mobilized industry at scale and leads in areas like electric vehicle manufacturing and adoption. However, China is held back by its still-rising transport emissions and relatively less stringent near-term policies, which contribute to its overall score slightly trailing Spain's.

Chile's performance at 6th place highlights climate leadership among developing economies. Chile earns high marks for ambition – it has set a clear long-term vision (for instance, aiming for 100% electric vehicles and electric public transport by 2040–2045) and is investing in renewable energy and pilot projects to support green transport. These efforts yield a strong overall score for an emerging economy. However, Chile faces financial and infrastructural constraints that could impede the full-scale implementation of its plans, tempering its otherwise impressive progress.

Conversely, Türkiye and Mexico (7th and 8th) illustrate the challenges when transport decarbonization is not yet a national priority. Their transport emissions continue to rise with insufficient countermeasures in place, resulting in lower scores across all KPIs. Both countries are in the beginning stages of deploying cleaner transport solutions and lag especially in the electrification of vehicles and development of sustainable transport infrastructure. On a positive note, each has opportunities to accelerate progress – for example, Mexico is beginning to develop an electric vehicle manufacturing base for export, and Türkiye has launched domestic electric vehicle initiatives. To capitalize on these opportunities, both countries will need much stronger government leadership and greater international support in order to significantly boost their performance.

Indonesia's last-place ranking (9th) underscores the difficulties faced by a rapidly urbanizing developing nation with heavy dependence on oil-fueled transport. Indonesia has thus far relied heavily on biofuels in its transport strategy, but this approach alone is not sufficient to put the sector on a net-zero trajectory. Its scores are extremely low in critical areas like policy support and current emissions trajectory. A much broader strategy will be required for Indonesia to catch up: the country will need to accelerate electric vehicle adoption, invest in public transit systems, improve fuel efficiency, and likely seek international climate finance and partnerships to overcome its substantial challenges.

Each country's approach has distinct strengths. Denmark and the Netherlands demonstrate how small, wealthy nations can implement bold policies (binding climate laws, early ICE vehicle bans) and build popular support for sustainable mobility (cycling culture, transit investment). Germany shows the impact of a comprehensive policy mix – from federal carbon pricing to sector targets – though its challenge remains converting plans into steep emission cuts this decade. Spain has a solid policy framework via the EU and is notable for decarbonizing electricity (benefiting transport indirectly) yet needs to accelerate EV adoption and freight modal shift. China's strength lies in industrial mobilization and scaling up new technologies (dominating EV manufacturing and adoption), but its weakness is the still-coal-heavy energy system and later net-zero timeline. Chile's high scores underline that emerging economies can be climate-progressive: it has a clear vision (100% electric vehicles and public transport by 2040–45) and is investing in the enabling green energy and pilot projects. However, Chile must overcome financial and infrastructural constraints to achieve full deployment. Conversely, Türkiye and Mexico illustrate the issues when climate policy is less prioritized – their transport emissions are rising with insufficient countermeasures. They have opportunities to leapfrog (e.g. Mexico manufacturing EVs for export, Türkiye developing domestic EV technology) but will need stronger government initiative and international support to boost their scores. Indonesia's low ranking highlights the difficulties for a developing nation with rapid urbanization and high oil dependency; its reliance on biofuels alone is not enough to put transport on a net-zero path. It will need a broader strategy including EVs, transit, and fuel economy improvements to catch up. This comparison was also asked to the selected firm managers related to the transport sector. The evaluations made by managers are given in Annex Section.

In conclusion, this comparative benchmark makes clear that while no country is yet on a perfect net-zero trajectory for transport, some are far closer than others. Denmark, Netherlands, and Germany have built holistic frameworks and are beginning to see results, setting examples for policy design and multisector coordination. China's large-scale deployment of clean transport technologies, especially in EVs, has positioned the country as a cost-reduction driver globally, potentially benefiting developing counties, benefiting other nations' transitions. Countries like Spain and Chile show that earnest action and alignment with international best practices can yield solid progress even outside the top-tier. On the other hand, the lowest-ranked countries must significantly ramp up their ambition and implementation; they will require not only domestic political will but also international climate finance and technology transfer to leap ahead. The transport sector worldwide has historically been a laggard in decarbonization – as evidenced by flat or rising emissions in most countries – but the emerging success stories provide a blueprint. By learning from each other's policies and innovations, and scaling up investments, these nine countries can collectively accelerate toward the mid-century net-zero goal, ensuring transport fully joins the global climate solution rather than remaining a problem. The rankings will evolve as policies tighten and technologies mature, and the hope is that today's stragglers can become tomorrow's leaders with concerted effort.

7 CONCLUSION

Türkiye's journey toward achieving net-zero emissions in the transport sector reveals both significant challenges and promising opportunities. Drawing on lessons from well-off countries like Denmark, Germany, and the Netherlands, as well as emerging economies such as China and Chile, Türkiye must accelerate its efforts to align with international best practices. Below is a synthesized analysis of Türkiye's current standing, strategic gaps, and actionable recommendations for a sustainable transition.

Current Position and Strategic Gaps

Türkiye's transport sector faces systemic challenges that mirror those of developing nations like Indonesia and Mexico. Transport emissions have risen by 30% since 1990 due to rapid motorization and economic growth, with electric vehicles (EVs) constituting less than 2% of new car sales as of 2025. Unlike Denmark or Germany, Türkiye lacks binding sector-specific targets, such as a phase-out date for internal combustion engine (ICE) vehicles or robust EV adoption incentives. Although the start of production by the domestic electric vehicle brand TOGG and the manufacturing of electric and hybrid light vehicles, buses, and trucks by numerous domestic firms represent significant steps, high costs limit the accessibility of these vehicles for wider segments of the population. Infrastructure gaps are pronounced: charging stations remain concentrated in major cities like Istanbul and Ankara, contrasting sharply with the Netherlands' nationwide density of one charger per three EVs. Rail freight accounts for less than 5% of cargo transport, far below Germany's 25% target for 2030, and renewable energy integration into transport lags despite Türkiye's 40% renewable electricity grid—a resource underutilized compared to Chile's 50% green-powered EVs.

The absence of a comprehensive climate law with enforceable milestones exacerbates these challenges. Türkiye's 2053 net-zero target lacks the interim benchmarks seen in Denmark's Climate Act or Chile's 2035 ICE ban. Financial incentives for clean mobility are minimal compared to Germany's €9,000 EV purchase bonus or China's $200B subsidies. Furthermore, Türkiye's reliance on fossil fuel subsidies strains public budgets without concurrent investments in alternatives, creating economic and environmental trade-offs.

Opportunities for Accelerated Transition

Türkiye possesses unique strengths that, if leveraged strategically, could position it as a regional leader. Its expanding renewable energy capacity—particularly in solar and wind—provides a foundation for powering EVs and green hydrogen production, akin to Chile's $45B green hydrogen pipeline. The domestic EV industry, exemplified by TOGG and other numerous domestic firms, offers export potential if scaled effectively, mirroring China's strategy to dominate global EV supply chains. Türkiye's geopolitical role as a logistics hub between Europe, Asia, and the Middle East presents opportunities to decarbonize freight corridors, inspired by the Netherlands' green port initiatives in Rotterdam.

Policy reforms are critical. Adopting Denmark's model of legally binding targets—such as a 2035 ICE ban and 30% EV sales by 2030—would provide clarity for investors and industry. Expanding financial incentives, including tiered subsidies (e.g., €5,000 for EVs, €10,000 for commercial fleets) and tax exemptions for charging infrastructure, could spur adoption. Rail modernization, with $2B+ allocated to electrify 1,500 km of track by 2030, would align with Spain's success in shifting freight to rail. Urban mobility improvements, such as low-emission zones in 10 cities by 2026, could replicate Amsterdam's zero-emission delivery mandates.

Critical Success Factors

Economic and Social Equity: Türkiye must ensure an inclusive transition across the country. Introducing a €58/month public transit pass, modeled after Germany's nationwide program, would enhance affordability amid fuel subsidy reforms. A "Just Transition Fund" for auto sector workers, akin to Spain's retraining programs at the SEAT plant, would mitigate job displacement.

International Collaboration: Joining initiatives like the Transport Decarbonisation Alliance would grant Türkiye access to technical expertise and climate financing, as seen in Chile's partnership with the Inter-American Development Bank. Bilateral partnerships with EU nations on green hydrogen corridors (e.g., İzmir-Rotterdam shipping routes) could attract investment and technology transfer.

Innovation and R&D: Allocating 2% of transport budgets to R&D—mirroring China's state-led innovation strategy—would support domestic battery production and charging technologies. Piloting hydrogen-fueled buses in Antalya and electric ferries in the Bosphorus, inspired by Denmark's maritime trials, would demonstrate commitment to cutting-edge solutions. Establishing concrete targets for pilot projects on hydrogen-powered trains and for the development of hybrid train technologies in the railway sector would also be beneficial.

Sector-Specific Priorities

- **Road Transport:** Accelerate TOGG and other EVs' production and phase out ICEs by 2035.

- **Aviation:** Invest in synthetic fuel plants, as Germany and Spain are doing, to develop sustainable aviation fuel (SAF).
- **Maritime:** Electrify ports using Rotterdam's shore power systems and explore green ammonia for shipping.
- **Rail:** For Türkiye, a modal shift from road to rail in freight transport is critical to achieving decarbonization objectives. Drawing comparisons with pioneering modal shift frameworks, such as Denmark's "One-Hour Strategy," substantial efforts must be undertaken to shift a significant share of road-based freight transport to rail by 2030. Such a transition is essential to reducing transport-related emissions and enhancing the sustainability of Türkiye's freight transport system .

Comparative Insights and Recommendations

Türkiye's net-zero transitions hinges on adopting a holistic strategy that integrates policy ambition, infrastructure investment, and equity. Denmark's success stems from binding climate laws and public-private collaboration, while China's dominance in EV production highlights the importance of scaling domestic industries. Chile's renewable-powered transport and Indonesia's biofuel initiatives offer lessons in leveraging natural resources. For Türkiye, immediate action is critical to avoid fossil fuel lock-in and capitalize on green industries. Establishing a national charging network (100,000 public chargers by 2030), implementing road pricing mechanisms, and mandating low-emission zones in cities would align with EU standards.

Türkiye's path to net-zero transport demands urgent, coordinated action. By integrating renewable energy into mobility, expanding public-private partnerships, and aligning with global frameworks, Türkiye can transform its transport sector from a laggard to a leader. The window for decisive action is narrow, but the blueprint for success—demonstrated by frontrunners like Denmark and China—is clear. Türkiye's transition to sustainable transport can be accelerated by ensuring long-term policy stability, prioritizing targeted investments and engaging in active international collaboration.

8 ANNEXS

Table 14: Evaluation of the FIATA

Rank	Country	Policy (A)	Emissions (B)	Infra & Tech (C)	Renewables (D)	Econ/Social (E)	Collab/Finance (F)	Innovation (G)	Modes (H)	Overall
1	**Denmark**	10	6	10	9	8	10	8	9	**8.8**
2	**Netherlands**	10	6	9	9	8	10	8	9	**8.6**
3	**Germany**	9	5	9	8	8	10	9	8	**8.3**
4	**China**	7	4	10	8	7	5	10	8	**7.4**
5	**Spain**	8	6	7	8	7	7	7	7	**7.1**
6	**Chile**	8	5	7	8	7	8	7	6	**7.0**
7	**Türkiye**	5	4	5	6	6	7	5	5	**5.4**
8	**Mexico**	5	4	4	4	5	5	5	4	**4.5**
9	**Indonesia**	5	3	3	5	5	6	4	3	**4.3**

Table 15: Evaluation of the UND

Rank	Country	Policy (A)	Emissions (B)	Infra & Tech (C)	Renewables (D)	Econ/Social (E)	Collab/Finance (F)	Innovation (G)	Modes (H)	Overall
1	**Denmark**	9	7	8	7	8	8	7	8	**7.8**
2	**Netherlands**	8	7	8	7	7	7	8	8	**7.5**
3	**Germany**	8	5	8	8	8	9	8	9	**7.9**
4	**China**	7	3	8	6	5	5	9	6	**6.1**
5	**Spain**	8	5	7	7	5	5	6	6	**6.1**
6	**Chile**	7	5	6	7	6	6	6	6	**6.1**
7	**Türkiye**	6	3	4	7	5	5	5	5	**5.0**
8	**Mexico**	6	3	4	3	4	5	4	4	**4.1**
9	**Indonesia**	5	2	3	5	4	6	3	4	**4.0**

Table 16: Evaluation of the Kayseri Transportation A.C.

Rank	Country	Policy (A)	Emissions (B)	Infra & Tech (C)	Renewables (D)	Econ/Social (E)	Collab/Finance (F)	Innovation (G)	Modes (H)	Overall
1	**Denmark**	9	6	8	10	9	10	8	10	**8.8**
2	**Netherlands**	9	6	10	10	8	9	9	9	**8.8**
3	**Germany**	9	6	8	9	9	9	9	9	**8.5**
4	**Chile**	6	7	6	9	7	8	7	7	**7.1**
5	**China**	4	5	9	5	7	7	10	8	**6.9**
6	**Spain**	6	6	6	7	7	6	8	7	**6.6**
7	**Türkiye**	4	3	5	6	5	5	5	6	**4.9**
8	**Indonesia**	3	2	2	3	3	6	4	4	**3.4**
9	**Mexico**	4	2	3	2	3	4	5	4	**3.4**

Table 17: Evaluation of the Turk Loyd Foundation

Rank	Country	Policy (A)	Emissions (B)	Infra & Tech (C)	Renewables (D)	Econ/Social (E)	Collab/Finance (F)	Innovation (G)	Modes (H)	Overall
1	**Denmark**	10	6	9	10	9	9	8	9	**8.8**
2	**Netherlands**	9	7	9	9	9	9	8	9	**8.6**
3	**Germany**	9	6	9	9	8	9	9	9	**8.5**
4	**China**	7	5	9	6	8	6	9	8	**7.3**
5	**Spain**	8	6	7	8	8	7	6	7	**7.1**
6	**Chile**	7	6	6	7	7	7	7	6	**6.6**
7	**Türkiye**	5	4	4	5	5	5	5	5	**4.8**
8	**Mexico**	4	3	3	3	3	4	5	4	**3.6**
9	**Indonesia**	3	2	3	4	4	5	4	3	**3.5**

Table 18: Evaluation of the UTIKAD

Rank	Country	Policy (A)	Emissions (B)	Infra & Tech (C)	Renewables (D)	Econ/Social (E)	Collab/Finance (F)	Innovation (G)	Modes (H)	Overall
1	**Denmark**	10	5	10	9	9	10	8	9	**8.8**
2	**Netherlands**	9	6	10	8	9	9	9	10	**8.8**
3	**Germany**	9	5	8	8	9	10	9	9	**8.4**
4	**Spain**	8	6	6	8	8	8	8	8	**7.5**
5	**Chile**	8	5	7	9	6	8	8	7	**7.3**
6	**China**	6	3	10	7	6	6	10	9	**7.1**
7	**Türkiye**	5	4	5	6	6	6	6	6	**5.5**
8	**Mexico**	6	4	5	4	5	6	5	5	**5.0**
9	**Indonesia**	5	3	3	4	5	6	4	4	**4.3**

Table 19: Evaluation of the Turkish State Railways (TCDD) Technical

Rank	Country	Policy (A)	Emissions (B)	Infra & Tech (C)	Renewables (D)	Econ/Social (E)	Collab/Finance (F)	Innovation (G)	Modes (H)	Overall
1	**Denmark**	10	6	9	10	9	10	9	9	**9.0**
2	**Germany**	9	6	8	9	9	9	9	8	**8.4**
3	**Netherlands**	9	6	9	9	8	9	8	8	**8.3**
4	**China**	7	5	10	6	7	6	10	9	**7.5**
5	**Chile**	7	6	7	8	8	8	7	7	**7.3**
6	**Spain**	8	5	7	8	8	8	7	7	**7.3**
7	**Türkiye**	5	4	5	5	5	5	6	5	**5.0**
8	**Mexico**	4	3	3	4	4	3	4	4	**3.6**
9	**Indonesia**	3	2	3	4	3	4	3	3	**3.1**

Table 20: Evaluation of the IGA Istanbul Airport Operation

Rank	Country	Policy (A)	Emissions (B)	Infra & Tech (C)	Renewables (D)	Econ/Social (E)	Collab/Finance (F)	Innovation (G)	Modes (H)	Overall
1	**Netherlands**	9	7	10	9	9	9	8	9	**8.8**
2	**Denmark**	10	5	9	10	9	9	8	8	**8.5**
3	**Germany**	9	6	8	7	9	9	9	8	**8.1**
4	**Spain**	8	7	8	8	8	8	7	8	**7.8**
5	**Chile**	8	6	6	9	7	8	6	6	**7.0**
6	**China**	7	4	8	7	6	7	9	7	**6.9**
7	**Türkiye**	6	6	5	7	5	6	6	5	**5.8**
8	**Mexico**	5	4	4	4	4	5	4	4	**4.3**
9	**Indonesia**	3	3	3	3	4	4	3	3	**3.3**

Table 21: Evaluation of the Türkiye Development Investment Bank

Rank	Country	Policy (A)	Emissions (B)	Infra & Tech (C)	Renewables (D)	Econ/Social (E)	Collab/Finance (F)	Innovation (G)	Modes (H)	Overall
1	**Denmark**	9	5	9	10	9	9	8	9	**8.5**
2	**Netherlands**	9	5	9	9	9	9	8	9	**8.4**
3	**Germany**	9	5	8	9	8	9	9	8	**8.1**
4	**Spain**	8	5	7	9	8	8	7	8	**7.5**
5	**Chile**	7	7	7	8	7	9	7	7	**7.4**
6	**China**	6	4	9	6	6	6	10	9	**7.0**
7	**Türkiye**	5	4	5	6	6	7	6	5	**5.5**
8	**Indonesia**	3	2	3	4	3	7	3	3	**3.5**
9	**Mexico**	3	3	3	3	3	4	5	3	**3.4**

Table 22: Evaluation of the Turkish Airlines

Rank	Country	Policy (A)	Emissions (B)	Infra & Tech (C)	Renewables (D)	Econ/Social (E)	Collab/Finance (F)	Innovation (G)	Modes (H)	Overall
1	**Germany**	7	8	8	8	8	8	8	8	**7.9**
2	**Netherlands**	7	8	7	8	8	8	7	8	**7.6**
3	**Denmark**	7	8	7	7	8	8	7	8	**7.5**
4	**Spain**	7	5	7	7	8	7	7	7	**6.9**
5	**Türkiye**	6	6	7	6	8	7	6	7	**6.6**
6	**China**	5	6	7	6	7	7	7	7	**6.5**
7	**Chile**	6	6	6	6	7	7	6	6	**6.3**
8	**Indonesia**	5	5	6	5	6	7	5	5	**5.5**
9	**Mexico**	5	5	5	5	5	5	5	5	**5.0**

Table 23: Evaluation of the SOCAR

Rank	Country	Policy (A)	Emissions (B)	Infra & Tech (C)	Renewables (D)	Econ/Social (E)	Collab/Finance (F)	Innovation (G)	Modes (H)	Overall
1	**Germany**	8	5	8	9	9	9	9	9	**8.3**
2	**Netherlands**	8	4	9	9	9	10	9	9	**8.4**
3	**Denmark**	9	4	9	10	9	10	9	9	**8.6**
4	**Spain**	7	5	6	8	8	7	7	7	**6.9**
5	**Türkiye**	6	4	5	7	6	8	6	8	**6.3**
6	**China**	6	3	10	6	8	7	10	10	**7.5**
7	**Chile**	7	6	5	9	9	9	7	7	**7.4**
8	**Indonesia**	2	1	2	4	3	8	3	2	**3.1**
9	**Mexico**	3	2	3	2	3	4	4	3	**3.0**

Table 24: Evaluation of the Project Experts

Rank	Country	Policy (A)	Emissions (B)	Infra & Tech (C)	Renewables (D)	Econ/Social (E)	Collab/Finance (F)	Innovation (G)	Modes (H)	Overall
1	**Denmark**	10	6	9	9	8	10	7	9	**8,5**
2	**Netherlands**	9	6	9	8	8	9	8	9	**8,3**
3	**Germany**	9	5	8	8	8	10	9	8	**8,1**
4	**China**	7	4	10	6	7	6	10	8	**7,3**
5	**Spain**	8	6	7	8	7	7	7	7	**7,1**
6	**Chile**	8	5	6	9	7	8	7	6	**7,0**
7	**Türkiye**	6	4	5	6	6	5	6	6	**5,5**
8	**Mexico**	6	4	4	4	5	5	5	4	**4,6**
9	**Indonesia**	5	3	3	5	5	6	4	3	**4,3**

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