Tracking Global Progress on Cleaner Transport

How to track the Global Effort to cut transport energy demand 25% and shift one-third to sustainable biofuels and renewables by 2035

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Project Background

The Introducing Measures, Pathways and Roadmaps for Optimizing Vehicle Efficiency and Electrification (IMPROVE) project is implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH and funded through the International Climate Initiative (IKI) of the German Federal Ministry for Environment, Nature Conservation and Nuclear Safety (BMUV).

IMPROVE supports the development of regulatory instruments that enhance vehicle energy efficiency and promote the electrification of vehicle fleets in its partner countries. It also fosters stakeholder coordination and knowledge exchange on vehicle efficiency, sustainable mobility, and climate change. In Kenya, the project is implemented in collaboration with the State Department for Transport, with a focus on designing regulatory instruments for vehicle efficiency—particularly for newly imported vehicles—while supporting the broader shift toward zero-emission transport solutions.

About Changing Transport

We enable the rapid development of zero emissions transport systems to shape a liveable and just future. GIZ works on changing transport towards a sustainable pathway and facilitating climate actions in mobility. We support decision-makers in emerging and developing countries through training and consulting services, as well as by connecting stakeholders. Our ultimate goal is zero-emission transport. You can learn more about our projects on www.changing-transport.org.

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Content

List of Tables

List of Figures

List of Acronyms and Abbreviations

BMUV	Federal Ministry for Environment, Nature Conservation and Nuclear Safety
COP	Conference of the Parties
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
EER	Energy Economy Ratio
FAO	Food and Agriculture Organization
GHG	Greenhouse gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
GST	Global Stocktake
ICAO	International Civil Aviation Organization
IEA	International Energy Agency
IKI	International Climate Initiative
ILUC	Indirect land use change
IMO	International Maritime Organization
LCA	Framework on life cycle GHG intensity of marine fuels
LCFS	Low Carbon Fuel Standard
NZE	Net Zero Emission
OECD	Organisation for Economic Co-operation and Development
OLADE	Latin American Energy Organization
pkm	passenger-kilometres
RED	Renewable Energy Directive
tkm	tonne-kilometers
UNFCCC	United Nations Framework Convention on Climate Change

Executive Summary

This methodological report proposes a framework to track global progress toward achieving two major objectives by 2035, as outlined in the *Towards resilient and low-emissions transport systems for people, development and the planet* Declaration (hereafter, “the Declaration”). The Declaration, led by Chile and announced at COP30 in Brazil, draws on the 2023 update of the International Energy Agency (IEA) Net Zero Roadmap and calls for:

- a 25% reduction in total transport energy demand relative to 2022 levels; and
- an increase in the share of sustainable biofuels and renewable energy to at least one-third of total transport energy use.

Tracking progress against these collective, global goals is coherent with the combined global objective of tripling renewable energy capacity and doubling the global average annual rate of energy-efficiency improvement by 2030 agreed at COP28 in Dubai.

It can also inform the next global stocktake (GST) at Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC), scheduled for the year 2028 and support emerging initiatives such as Triple Up, Double Down, Electrify Now (“Getting to 35 by ’35”), which highlight the importance of end-use electrification as a key delivery mechanism for achieving COP28 goals.

Transport currently accounts for roughly 20% of global energy-related greenhouse gas (GHG) emissions, with road transport representing over three-quarters of these emissions. Despite temporary declines during the COVID-19 pandemic, emissions have continued to rise – especially in emerging economies – driven by population and income growth, expanding freight activity, and persistent reliance on fossil fuels.

The report identifies three strategic pillars for reducing transport GHG emissions:

1. Systemic changes that reduce mobility needs and promote low-energy modes such as public transport, rail, and two-wheelers.
2. Technological developments improving energy efficiency, such as electric drivetrains, lightweight materials, and aerodynamic design.
3. Low-emission energy options, particularly the scaling up of sustainable biofuels and low-emission electricity.

It acknowledges that all these pillars are included in the definition of the goals proposed, enabling them to account for contributions that derive from all transport modes and a broad range of vehicle and energy technologies.

A core methodological challenge lies in how to measure progress across diverse energy forms and accounting systems. The report distinguishes between primary energy, final energy and useful energy. Primary energy is energy in its original form before any transformation, conversion or distribution. Final energy is the energy consumed by end-use sectors after transformation and distribution losses. Useful energy is the portion of final energy effectively converted into the energy service required (e.g. motion).

The report recommends using both a final energy and a useful energy accounting approach for:

- Total energy demand in transport and its evolution.
- The share of sustainable biofuels and renewables, reflecting differences in end-use efficiency across powertrains.
- The shares of electricity and renewable electricity in transport energy demand.
- The shares of aviation and (when available) shipping fuels that are certified as sustainable in internationally agreed frameworks in the total of all renewable fuels used in transport.

The framework therefore combines final- and useful-energy indicator because tracking final energy alone would risk understating the progress that can be achieved by electrification, as it significantly improves conversion efficiency.

The IEA World Energy Balances dataset is identified as the most reliable and comprehensive global data source for this purpose, given its coverage, transparency, international consistency and regular updates.

The report acknowledges the value of primary energy accounting as an alternative approach to tracking total energy demand reductions, but underscores challenges for its proper tracking, given limitations in data availability by production pathways.

The analysis underscores that slower-than-expected electrification – particularly in road and rail transport – would significantly hinder achievement of the overall targets. By contrast, shortfalls in biofuel or hydrogen deployment would have more limited impacts on aggregate energy-demand and renewable-share targets. Conversely, accelerated electrification would generate substantial benefits, enabling additional savings in final energy demand and higher renewable energy shares.

The report also underscores the complexity of defining “sustainable” biofuels, given differing international standards and methodologies for assessing lifecycle GHG emissions, land use change, and broader environmental and social impacts. It reviews ongoing international efforts – by International Civil Aviation Organization (ICAO), International Maritime Organization (IMO), and IEA – to harmonize sustainability criteria and data reporting.

Given current data limitations and definitional uncertainties – particularly regarding sustainable fuels – the report proposes a pragmatic and policy-relevant tracking framework. A pragmatic tracking approach is therefore proposed, as follows:

1. Use IEA energy balance data to monitor final energy consumption by transport mode and product type in detail, complementing these data with targeted information from sector-specific analyses. Complementary data are key to ensure that the tracking integrates timely information, since IEA data on energy demand only become available with a two-year time lag. At the same time, complementary, sector-specific data sources are also sufficient to guarantee high levels of confidence.
2. Include tracking of renewable shares in electricity generation, based on average values at the country level.
3. Apply standardized conversion factors (from literature), combined with data on energy use by mode. to estimate useful energy shares.

4. Conduct periodic methodological reviews (every five years) to reflect technological advances, data improvements, and evolving definitions of sustainability.

These methodological revisions are particularly important for cases where the data available in the IEA World Energy Balances have limitations. This is the case for hydrogen production (not tracked by primary form of energy, as in the case of electricity generation) and biofuels (not distinguished based on their sustainability profiles).

This pragmatic yet scientifically robust framework aims to provide credible, comparable, and policy-relevant indicators for tracking global progress toward cleaner, more energy-efficient transport systems.

The proposed approach enables timely and credible tracking of the Declaration’s targets and can provide a meaningful input to future UNFCCC GST and related international processes. Continued improvements in official statistics – particularly regarding sustainable fuels and emerging energy carriers – will further strengthen the robustness of the framework over time.

Introduction

In November 2025, the Declaration "*Towards resilient and low-emissions transport systems for people, development and the planet*" was officially launched at COP30 in Belém, Brazil, and endorsed by eleven countries. The Declaration establishes a set of globally relevant 2035 targets for transport and climate change initiatives, particularly in the areas of electrification, energy efficiency and low-emissions, sustainably produced fuels.

The "global effort" sets a mid-term benchmark for the decarbonisation of the transport sector to be achieved by 2035, calling for:

- A 25% reduction in transport energy demand; and
- An increase in the share of sustainable biofuels and renewable energy to at least one third of total energy consumption in transport.

Source: Natalia Meza, GIZ Chile

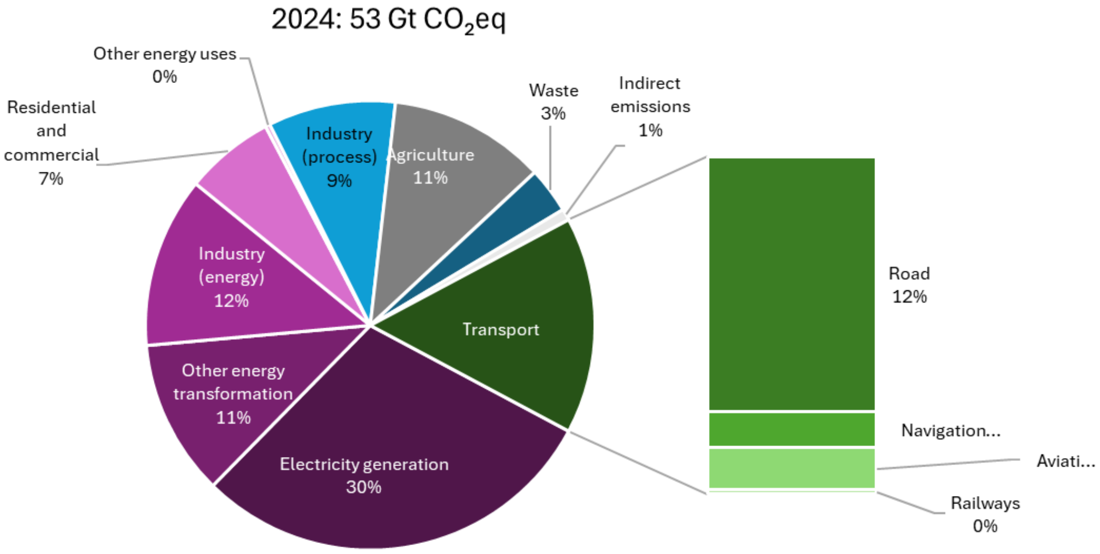
This report aims to support the implementation of this initiative by providing a robust methodology to track key indicators and monitor progress towards achieving these targets.

Reliable and comparable tracking of progress is essential to support international accountability, inform policy and investment decisions, and provide an evidence base for future UNFCCC GST and related international processes. This report therefore focuses on practical and internationally consistent indicators that can be implemented using available global data.

Context

As of 2024, the transport sector was responsible for around one-fifth of global energy-related GHG emissions and 16% of all GHG emissions globally (Figure 1). Within transport, road accounted for more than three-quarters of the total emissions and a similar proportion of final energy use (EDGAR, 2025). Within road, roughly 60% of all emissions and energy demand are attributable to light vehicles, while trucks and buses account for the remaining share (IEA, 2020). Navigation and aviation accounted for roughly the same share of transport emissions, 11%. Rail emissions were 1% of the total of those from all transport modes.

Figure 1: GHG emissions in 2024 by sector



Source: elaboration developed for this report, based on data from EDGAR, 2025

- After a temporary Covid-19-related decline, global transport emissions are rising (Figure 2). This trend reflects a combination of rising transport activity – measured in passenger-kilometers (pkm) and tonne-kilometers (tkm) – and structural factors affecting energy demand and emissions. These reflect:
- Growing population and income levels
- Shifts in modal mix towards more energy intensive options.[1]
- Limited improvements in energy efficiency across modes.
- Continued reliance on oil-based fuels in most transport segments
- Limited scope for carbon capture technologies to be cost-effective or technically viable at scale for highly distributed transport energy end uses.

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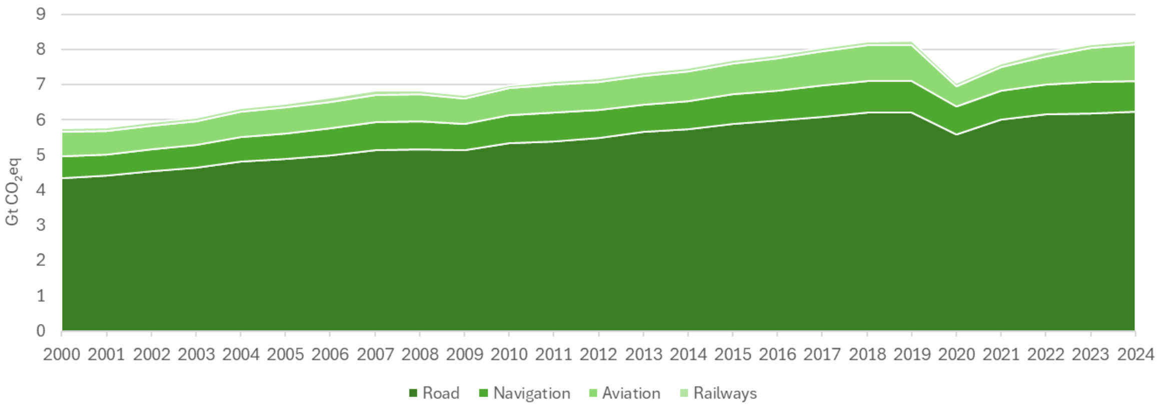
[1] This includes, for passenger transport, shifts from buses and two wheelers towards cars, a growing reliance on air travel, with income growth. In freight transport, it includes a move from more frequent hauling of bulk, low-value goods towards goods with higher value, a parallel increase of the share of freight deliveries occurring by road (rather than rail and ship), and more frequent maxing of haulages based on volumes rather than weight.

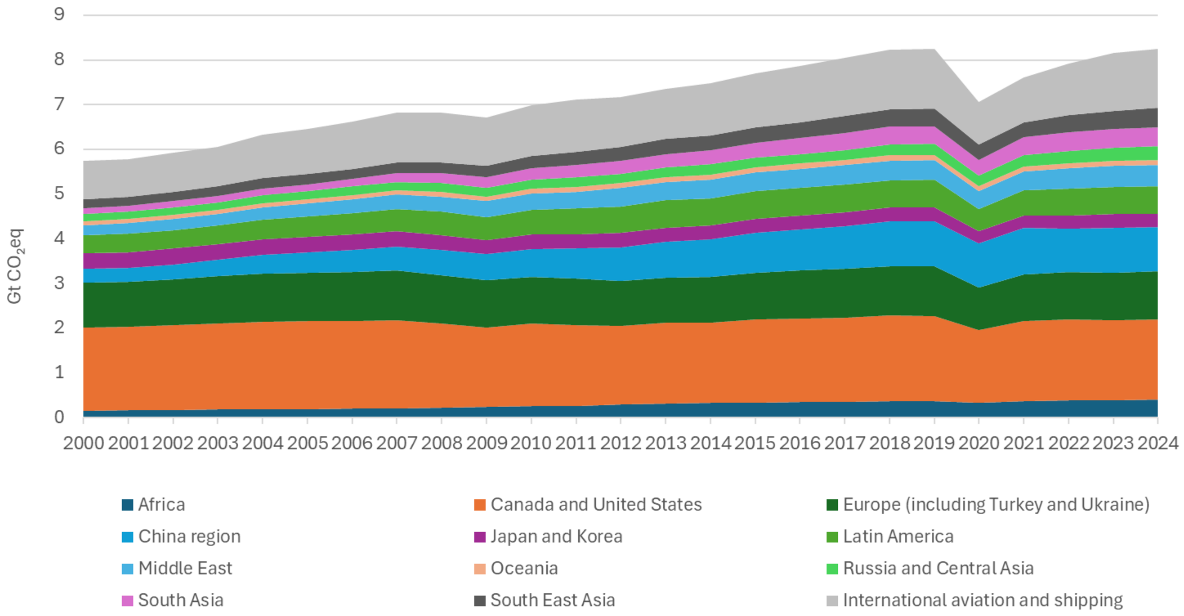
Figure 2: Global GHG emissions in transport, by mode, 2000-2024



Source: elaboration developed for this report, based on data from EDGAR, 2025

Growth in transport energy demand and GHG emissions has been particularly strong in emerging economies (Figure 3). This reflects faster growth in key drivers – population and income growth – in comparison with the pace observed in developed economies. It is also linked to rising demand for goods and freight transport services, continued reliance on private vehicles in many regions[2] and increasing aviation demand as expanding middle classes gain access to air travel (Shafer and Yeh, 2020, Schafer and Victor, 2000, Sims et al., 2014, IEA, 2023, Benitez et al. , 2025, ITF, 2023).

Figure 3: GHG emissions in transport, by global region, 2000-2024



Source: elaboration developed for this report, based on data from EDGAR, 2025

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[2] This occurs especially in the absence of targeted investments allowing to improve the quality and the value proposition of rail and shared or public transport services.

The main options for reducing transport GHG emissions therefore involve accelerating changes in both transport activity and energy intensity, while expanding the use of low-emission energy sources.

Reductions in energy demand can be achieved through changes in activity patterns – typically measured in pkm and tkm – and improvements in energy intensity (energy per unit of transport service, commonly measured in MJ/pkm or MJ/tkm), without reducing accessibility. These measures must be complemented by a growing share of low-emission energy options across all transport modes. This is the case across all modes, as illustrated further in Box 1.

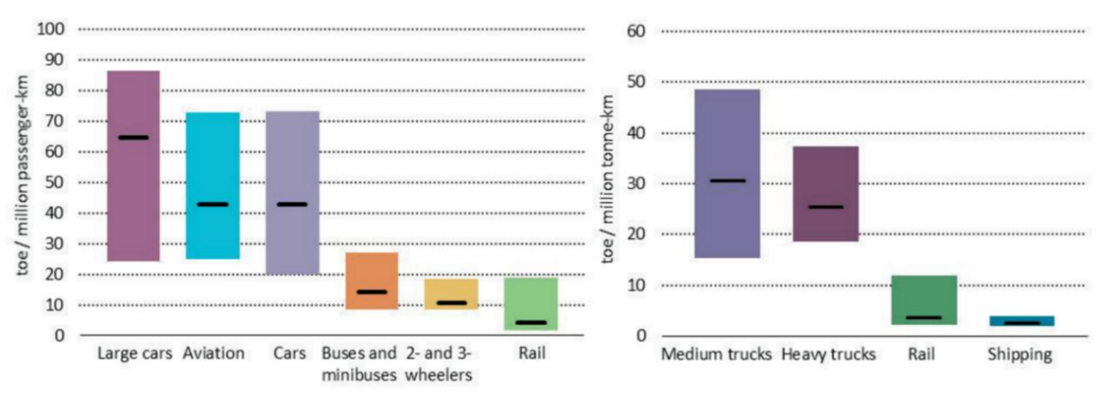
Box 1. Main strategies to curb GHG emissions

Significant reductions in transport activity and energy intensity – achievable without compromising accessibility – are possible through a range of solutions, including systemic changes and technological developments.

Systemic changes

Systemic changes are those that allow trips to be shortened, reducing energy use and GHG emissions by reducing the need for mobility (and hence also resulting in lower activity demand), and enabling greater reliance on modes that need less energy to deliver passenger and freight transport services.

Figure 4. Energy intensity of different transport modes



Source: IEA, 2019

For passenger mobility, public transport, rail and two wheelers tend to be significantly less energy-intensive per pkm than travel by private cars or air transport. For freight transport, navigation and rail are far less energy and emission intensive per tkm than road transport vehicles (Figure 4)[3]. Energy-intensity gaps are particularly pronounced in contexts that remain largely reliant on combustion technologies and can also vary significantly across mission profiles.[4]

Technological developments

Technological developments relate primarily to the characteristics of different powertrain options within a given transport mode and the amount of energy that they need to deliver transport services. Key examples include combustion engines or electric motors and batteries.

Other technological developments include improvements in aerodynamics and vehicle weight reduction, which can further reduce the amount of energy required to deliver transport services.

Low-emission energy options

Increases in the share of low-emission energy options can be achieved by scaling up the contribution of forms of energy that are characterized by low life-cycle emissions.

Options that have demonstrated relevance in this context include low-emission and sustainably produced fuels and – as electric mobility gains traction[5] – low-emission electricity. Among fuels, bio-based options currently account for the largest market share. Going forward, other fuels, including hydrogen and its derivatives (in the European Union, these are defined as fuels whose energy content is not derived from biogenic sources) are also being explored, even if their current market shares are still at very low levels.

Background of the quantified global climate goals for transport

In 2023, an update of the IEA Net Zero Roadmap (IEA, 2023) outlined a pathway enabling the alignment of the energy sector with a 1.5°C trajectory, tracking developments in policy, technology, investment, innovation, and costs. This Roadmap can effectively support the first GST that took place at the COP28 to the UNFCCC in December 2023, with the aim to track progress toward the Paris Agreement's goals and inform enhanced climate action. In particular, it offers the opportunity to establish quantified transport targets, complementing the ones already set by the GST for the whole economy – i.e. tripling renewable energy capacity and doubling the rate of energy efficiency by 2030 (UNFCCC, 2024) – and also responding to the call by the IEA to establish a quantified global goal for 2030 and beyond could accelerate action to decarbonize the road transport sector (IEA, 2024).

In 2025, a targeted note proposed sector-wide goals for transport decarbonization, taking into consideration all the strategies identified in the earlier section (Zhang-Billert and Welle, 2025). This proposal factors in a transition away from internal combustion engine through electrification; the scaling up low- emission fuels; modal shifts bolstering energy efficiency through public transport, active mobility, and rail; and broader renewable energy policies to facilitate integration with transport. It leverages the 2023 update of the IEA Net Zero Roadmap to define the following sectoral target, for transport: a 25 percent reduction in transport energy consumption (compared to 2022) by 2035 and a shift to 35 percent of "green fuels".

Such a goal, illustrated in Figure 5, is intended for all transport modes and a range of technologies, including electrification and shifts to more sustainable travel such as rail and public transport.

In November 2025, the Declaration was officially launched at COP30 in Belém (Brazil). The Declaration was led by Chile and endorsed by Brazil, Colombia, Costa Rica, Honduras, the Dominican Republic, Slovenia, Norway, Spain, Portugal and Austria (Government of Chile, 2025). It took inspiration from the IEA Net Zero Roadmap and it reflects a strong and diverse coalition united in accelerating the transition toward resilient, low-emission mobility (Changing Transport, 2025b).

The Declaration refers to a global effort of:

- Achieving, globally, a 25% reduction in transport energy demand relative to 2022 levels by 2035.

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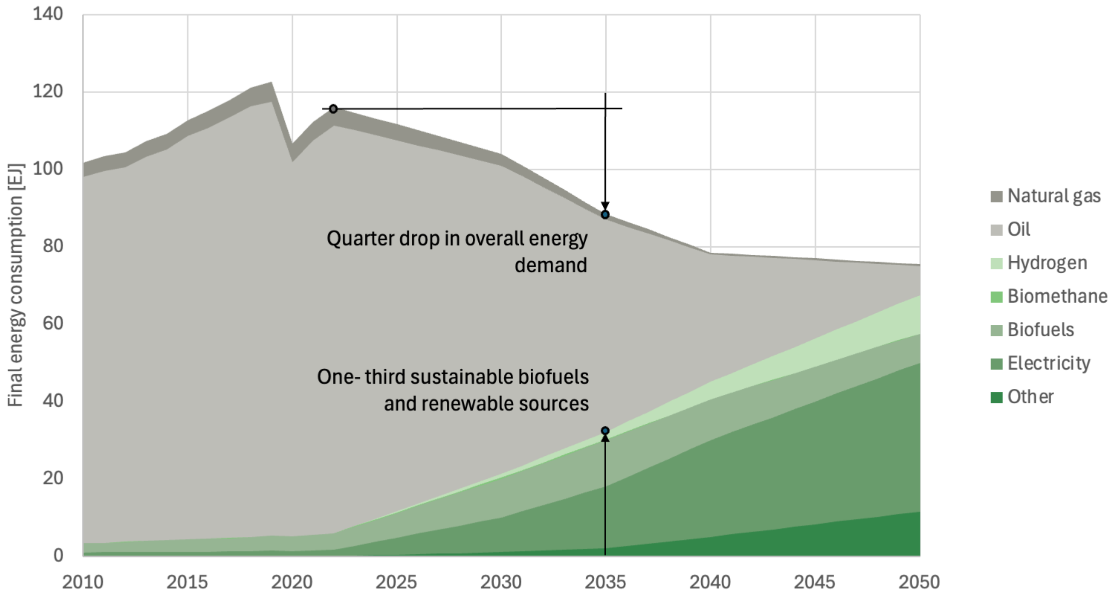
[3] An example of a systemic change is offered by moves favouring compact, transit-oriented urban development, with mixed use areas, for passenger transport, as this is structurally more likely to be paired with shorter trip distances and better suited for the cost-effective deployment and use of less energy intensive forms of public transport, in comparison with urban environments embedding large areas of urban sprawl (IEA, 2016, OECD, 2021, ITF, 2023).

[4] For example, energy demand is much higher, for combustion engine vehicles without regenerative braking for trips with frequent stops (as they require their frequent use in ways that are misaligned with optimal design conditions) than it is for electric vehicles (as they are less affected by losses from variable loads and benefit from regenerative braking).

[5] Data on vehicle sales show major ongoing transformations in the mix of powertrains used in transport, with resilient changes taking place over several years, making the contribution of electricity far more relevant in the transport energy mix, with respect to past developments. This underscores the need to take due account for this contribution, going forward.

- Increase in the share of sustainable biofuels and renewable energy to at least one-third of total transport energy use (Changing transport, 2025a).

Figure 5: Transport energy consumption by type of energy in IEA's Net Zero Emission (NZE) scenario.



Source: Zhang-Billert and Welle, 2025, based on IEA, 2023, adding updated historical data with greater granularity, until 2022 (base year of these analyses).

The Declaration and its goals are coherent with the UAE Consensus and associated pledges to pursue a combined global objective of tripling renewable energy capacity and doubling the global average annual rate of energy-efficiency improvement by 2030, developed at COP 28 in Dubai (UNFCCC, 2023). The Declaration is also coherent with emerging international work that identifies end-use electrification as a critical delivery mechanism for achieving the COP28 goals, and in particular with a *Triple Up, Double Down, Electrify Now* ("Getting to 35 by '35") initiative, which proposes elevating electrification within international energy and climate agendas as a practical means of translating commitments on renewables and efficiency into real-economy emissions reductions and energy-system transformation.

What to track, why and how?

This analysis focuses on the global effort to track progress against the objectives adopted in the Declaration to achieve a 25% reduction in transport energy demand relative to 2022 levels by 2035 and increasing the share of sustainable biofuels and renewable energy to at least one-third of total transport energy use.

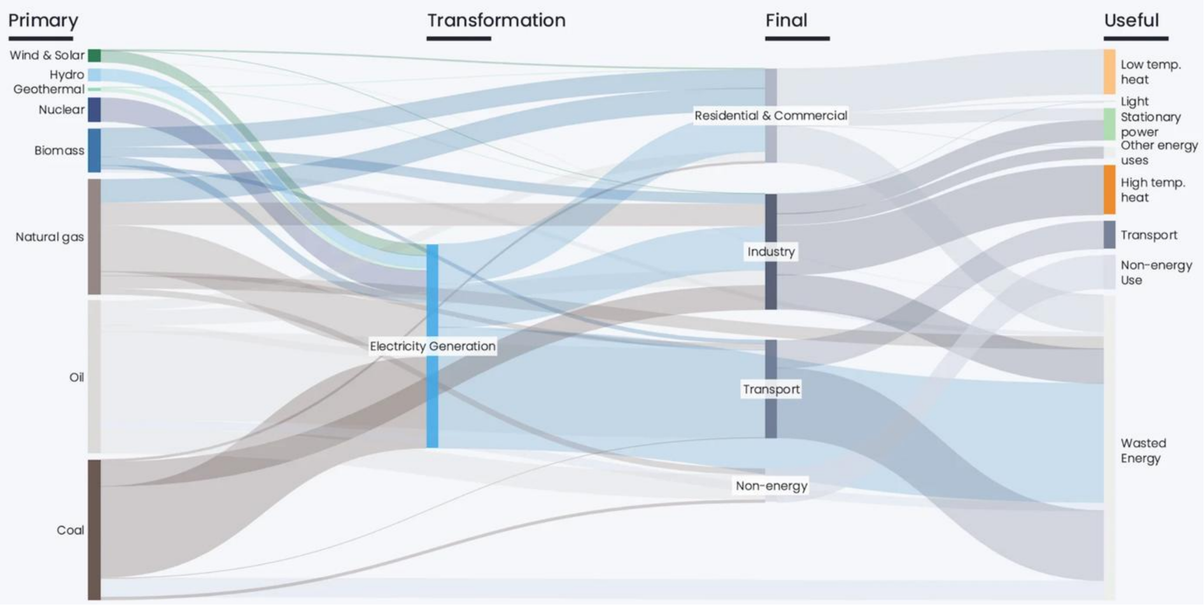
It aims to provide guidance on ways to document progress, proposing practical and actionable approaches to define indicators that could inform the next UNFCCC GST, due in 2028. It does so in a way that accounts for different considerations, including the relevance of specific forms of energy and different accounting approaches, complexities related to the sustainability profile of different energy types and the importance of an authoritative and reliable source of international data.

Relevance of specific forms of energy and different accounting approaches

Enabling the achievement of the Declaration requires a strong capacity to track specific forms of energy (e.g. fuels or electricity) and also to differentiate across energy accounting approaches, in particular between primary energy, final energy and useful energy. As shown visually in Figure 6:

- Primary energy is the energy in its original form before any transformation, conversion, or distribution. It includes losses that occur upstream of final energy accounting, such as those related to fossil energy extraction, chemical conversions (e.g. in refining or other fuel synthesis processes) and in electricity generation.
- Final energy is the energy consumed by end-use sectors (transport, industry, buildings, agriculture, etc.) after transformation and distribution losses have already been accounted for.
- Useful energy is the part of final energy that is actually converted into the energy service needed (e.g. heat, motion, or light).

Figure 6: Graphical visualization of the primary, final and useful energy concepts across the global energy system



Source: EMBER, 2026

In transport, final energy can be the energy contained in a vehicle tank (e.g. as a petroleum product or a biofuel) or the electricity delivered by a charging station to a vehicle battery. Typical products that can be tracked in the form of final energy use and are currently used in significant amounts include petroleum derivatives (gasoline, diesel, jet fuel, fuel oil in maritime transport), biofuels or electricity.

In transport, useful energy is the mechanical work required to move vehicles (irrespective of the mode). It changes based on powertrain and vehicle characteristics. Generally speaking, larger, heavier and faster vehicles need more useful energy than smaller, lighter and slower ones. If measured with respect to pkm and tkm, rather than vkm, it is also affected by vehicle capacity and load profiles.

Tracking primary energy used to deliver transport services is possible, but it requires complex assessments, based on life-cycle analysis of energy carriers, with a focus on well-to-wheel scope[6] . This exercise is especially complex for biofuel production pathways, as biofuels require multiple forms of energy inputs, not only related to the energy system (the plants converting agricultural feedstocks into fuels), but also with the agricultural sector (e.g. for the production and use of fertilizers). Differences across electricity generation technologies also affect this assessment.[7]

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[6] Adding vehicle manufacturing and infrastructure construction to the analysis would require even more complexity.

[7] In the IEA energy balances, nuclear electricity is converted to primary nuclear heat using a 33% energy conversion factor, geothermal electricity is converted in geothermal heat using a 10% default factor, and thermal electricity generation is assessed tracking both primary energy inputs and electricity outputs (IEA, 2023 and IEA, 2004). Additional complexities, requiring the attribution of primary energy to different forms of final energy (heat or electricity) also arise from the combined production of heat and electricity.

Box 2. Implications related to energy efficiency

Energy efficiency is a relevant concept in this context, as it measures how much of the input energy is successfully converted into the desired output (useful energy), rather than being lost as waste (heat, noise, friction), according to the following relationship:

$$\text{Energy efficiency} = \frac{\text{Useful energy (or work)}}{\text{Energy input}}$$

Its accounting can be based on the use of final or primary energy, at the denominator.

Due to significant differences across powertrain technologies, it is especially important to ensure that energy efficiency is adequately considered. If final energy is the parameter chosen at the denominator, differences in energy efficiency to be considered are linked to the performance of powertrains at the mode and vehicle level (i.e. across road, rail, aviation and navigation, and across different vehicles within these categories[8]). These gaps are also affected by the nature of the duty cycles taken into consideration. One more layer of differentiations applies when primary energy is the parameter to be taken into consideration at the denominator, to account for differences in the conversion or primary energy (e.g. coal, or oil) into final energy (e.g. electricity).

The following tables provide a summary of relevant ratios (with related sources) that can enable the assessment of different energy accounting approaches for a selection of representative transport vehicles, modes, powertrains and fuel production pathways. Table 1: Useful to final energy ratios for combustion and electric powertrains by mode refers to $\frac{Useful\ energy}{Final\ energy}$. Table 2: Primary to final energy ratios for selected fuel production pathways refers to $\frac{Primary\ energy}{Final\ energy}$. Figure 7 provides an overview of a broad set of combinations, reporting useful to primary energy ratios (obtained dividing useful to final energy ratios by primary to final energy ratios) for different powertrain and energy production pathways.

Table 1: Useful to final energy ratios for combustion and electric powertrains by mode

Mode	Combustion	Fuel cell	Electricity	Sources
Road	0.2 (0.15–0.25) for spark ignition 0.25 (0.18–0.4) for compression ignition	0.5 (0.45–0.6)	0.75 (0.65–0.85)	Serrano-Guevara et al, 2025, GFEI 2023, IEA, 2019, ICCT, 2021 and Hjelkrem et al., 2020 for combustion and electric; Handwerker et al., 2021 and Halder et al. 2024 for fuel cell
Rail	0.35 (0.3–0.5)	0.5 (0.45–0.6)	0.8 (0.7–0.9)	IEA, 2019, Popovich et al, 2021, Tostes et al, 2024 and IEA ETSAP, 2011 for combustion and electric; Ding and

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[8] Such as two wheelers, cars, buses, light commercial vehicles, medium and heavy trucks, for road.

				Wu, 2024 and Ruf et al., 2019 for fuel cell
Domestic aviation	0.25 (0.2–0.3)	0.45 (0.4-0.55)	0.5 (0.4–0.7)	Epstein, 2024 and Burzlaff, 2017 for combustion, Zamboni, 2018, Schäfer et al, 2018, ICCT, 2022, Duffy and Hansen, 2018, Hepperle, 2012, Simanidou et al, 2024, Pattanayak and Mavris, 2025 and ITF, 2021 for electric; Oh et al., 2023 for fuel cell; USNA, n.d. for propulsive efficiency
International aviation	0.33 (0.25–0.4)	0.35 (0.3-0.45)	0.3 (although not yet relevant)	
Domestic navigation	0.35 (0.3–0.4)	0.35 (0.3–0.45)	0.7	MAN ES, 2019, Wang and Zhao, 2019, Smith et al., 2013 for combustion, Kanchiralla et al., 2025 and Park et al., 2022 for electric; Oh et al., 2023 for fuel cell; USNA, n.d. for propulsive efficiency
International navigation	0.45 (0.35–0.5)	0.45 (0.35–0.5)	0.7 (0.55-0.75), although not yet relevant	

Notes: values in brackets refer to ranges of efficiency found in literature. Differences across modes reflect specific characteristics of the technologies and the duty cycles. For example, the efficiency of electric aviation is negatively affected by battery mass, in contrast with the case of land-based transport modes.

Table 2: Primary to final energy ratios for selected fuel production pathways

Fuel	Primary to final energy ratio
Fossil fuels	1.15 (1.2-1.1)
Biofuels - Biochemical - Conventional (cereals)	1.73 (1.8-1.7)
Biofuels - Biochemical - Conventional (sugar cane)	2.7 (2.8-2.7)
Biofuels - Biochemical - Advanced feedstocks	2.9 (3-2.7)
Biofuels - Biochemical (ATJ) - Conventional (cereals)	2 (2.2-1.9)
Biofuels - Biochemical (ATJ) - Conventional (sugar cane)	3.1 (3.5-3)
Biofuels - Biochemical (ATJ) – Advanced	3.3 (3.8-3)
Biofuels – Oleochemical	1.4 (1.5-1.3)
Biofuels - Thermochemical - Advanced feedstocks	1.7 (1.8-1.6)
Hydrogen - Low-emission electricity, requiring transport	1.6 (1.7-1.5)
Hydrogen - Low-emission electricity, decentralized production	1.5 (1.6-1.4)

Hydrogen - Fossil based, requiring transport	1.6 (1.7-1.5)
Hydrogen - Fossil based (CCS), requiring transport	1.7 (1.9-1.5)
Hydrogen - Fossil based (methane pyrolysis), requiring transport	2.9 (3.2-2.6)
E-fuels - Liquid hydrocarbons	2.6 (2.7-2.5)
E-fuels – Methanol	2.3 (2.4-2.2)
E-fuels – Methane	2 (2.1-1.9)
E-fuels – Ammonia	1.8 (1.9-1.7)
Recycled Carbon Fuels (with low-emission hydrogen)	2.2 (2.3-2.1)

Notes: ATJ = Alcohol to jet; CCS = carbon capture and storage.

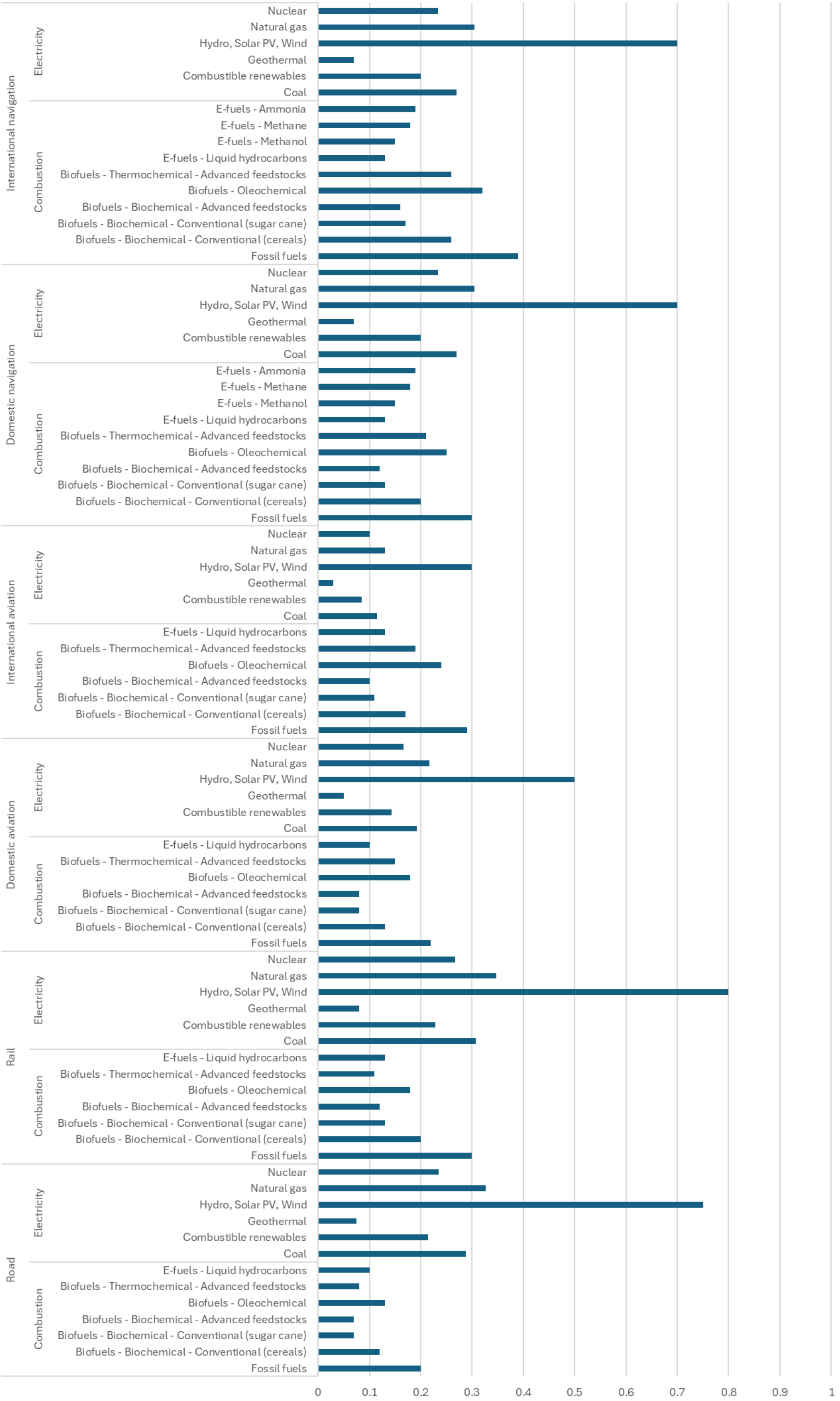
Sources: as indicated in Table A1.1 in Cazzola et al., 2024.

Table 3: Primary to final energy ratios for selected electricity production pathways

Primary energy	Primary to final energy ratio
Coal	2.6 (2.2-3)
Combustible renewables	3.5 (2.5-5)
Geothermal	10
Hydro	1
Natural gas	2.3 (1.7-2.6)
Nuclear	3
Oil	3.2 (2.9-3.5)
Solar photovoltaic	1
Solar thermal	3
Wind	1

Source: IEA, 2023, IEA, 2004, IEA, 2008, IEA, 2007, Kampman et al, 2010.

Figure 7: Useful to primary energy ratios for selected fuel production pathways



Note: hydrogen-based pathways are not displayed to reduce complexity.

Sources: central values in Table 1 to Table 3.

Complexities related to the sustainability profile of different biofuels

Different types of energy and accounting methods related to fuel and electricity production are not the only relevant parameters that define sustainable energy options. Other considerations are also shaping the sustainability characteristics of different energy options. These include impacts on life-cycle GHG emissions, land use (direct requirements and indirect effects), water, soil health, air quality, biodiversity (also linked to land use), local environmental impacts (which may be linked to GHG emissions and other aspects, such as chemical leakages), and social developments (e.g. with respect to labour laws or rights of local and indigenous communities). They also include impacts on food and energy prices (possibly related to land use and related to supply and demand dynamics of the agricultural and forestry sectors).

The sustainability of biofuels is still subject to challenges. Direct and indirect life-cycle GHG emissions are complex to characterize, as they depend on the feedstock used, agricultural practices, conversion pathways and other considerations (Bouter et al., 2024, IPCC, 2022, National Academies of Sciences, Engineering, and Medicine. 2022). Indirect effects related to land use change are particularly hard to quantify, even if there is consensus that some of the feedstocks that are paired with greater risks. Risks of fraud add one more layer of uncertainty (van Grinsven, 2021, European Court of Auditors, 2016, European Court of Auditors, 2023). While significant efforts have taken place, both in specific jurisdictions and in international fora[9], to narrow uncertainties and make progress towards the achievement of greater consensus and therefore also better international recognition of different pathways, the subject has been and is still the object of international disputes (WTO, 2025, WTO, 2024).

Different initiatives have been developed to try to achieve greater international harmonization. A recent effort by the IEA, also in support of Brazil's G20 Presidency, mapped global certification and regulation schemes and examined plausibility of shared criteria (IEA, 2024). The most prominent case helping move towards greater international harmonization is the recent update of the eligibility criteria for sustainable aviation fuels released in the context of the Carbon Offsetting and Reduction Scheme For International Aviation (CORSIA) (ICAO, 2025). For international shipping, the International Maritime Organization (IMO) has also released guidelines on the life-cycle GHG intensity of shipping fuels (IMO, 2024), in the context of its Strategy on Reduction of GHG Emissions from Ships (IMO, 2023), its framework on life cycle GHG intensity of marine fuels (LCA) (IMO, 2024) and the IMO Net-Zero framework (IMO, 2025a), despite its recent adjournment for a year (IMO, 2025b).

However, even accounting for these efforts, no simple and internationally agreed solution to define sustainable biofuels currently exists, especially for the road sector (currently the main biofuel consumer). Different jurisdictions still adopt their own specific approaches, especially with respect to indirect land use change (ILUC) impacts.

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[9] These include those dealing with cross-border flights – at the ICAO, in the context of the CORSIA (ICAO, 2025) – and international shipping – at the IMO, in the context of its Strategy on Reduction of GHG Emissions from Ships (IMO, 2023), its LCA (IMO, 2024) and the IMO Net-Zero framework (IMO, 2025).

A sense of the complexity of these aspects is given by ICAO's CORSIA, which is probably the most advanced case in terms of international alignment. Its 2025 update regarding the identification of eligible fuels (ICAO, 2025) relies on the combination of default core LCA values for GHG emissions/MJ of energy in the fuel, actual core LCA value calculated with the use of specific methodologies, default ILUC values directly applicable to feedstocks produced in land that was converted before 1 January 2008. For land use conversion after this date, it relies on direct land use change (DLUC) emissions, also associated with specific methodologies. For other sustainability aspects, CORSIA relies on specific eligibility requirements and certification schemes involving authoritative bodies qualified to perform their accreditation, as well as independent audits (ICAO, 2025).

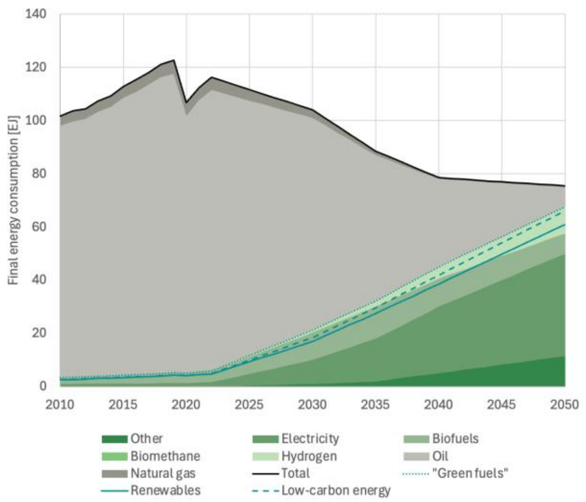
Challenges for the quantification of the goals in light of differences in energy accounting methods and other shortcomings

The targets identified in the Declaration refer to final energy demand values as reported by the IEA in its energy balances. These are not associated with specific low-emission and/or sustainability requirements, as the IEA does not differentiate between biofuels with different sustainability profiles in its energy balances and as it does not track details on how hydrogen and its derivatives are produced, nor whether they are from low-emission or renewable energy.

Specific sustainability frameworks, however, exist in the context of international aviation (ICAO, 2025) and are also being developed for international shipping (IMO, 2024). Due to the relevance of sustainable fuels for both long-distance aviation and shipping, where electrification is not a cost competitive option and will likely not be for a long time, tracking the share of fuels supplied according to internationally agreed sustainability frameworks in the total demand of biofuels, hydrogen and hydrogen derivatives can help bridging the issue of the lack of this information in IEA data.

Figure 8 illustrates how different ways to consider groups of final energies lead to slightly different results in terms of energy shares. Green wedges refer to the “green fuels” taken into consideration by Zhang-Billert and Welle, 2025 using the data from IEA, 2023, without differentiating based on different primary energy sources. Lines overlayed to the wedges show shares of renewable energy and low-emission energy. Renewables include biofuels, electricity, hydrogen and hydrogen derivatives from renewable sources. Low-emission energy also includes other pathways to generate electricity and produce hydrogen not reliant on renewables (e.g. from nuclear energy or gas with carbon capture and storage), based on data from IEA, 2023. Results are shown in terms of final energy demand (left) and in terms of useful energy equivalents (right). When taking a useful energy accounting approach, the figure shows that shares of green fuels, renewable and low-emission energy increase with respect to those arising from a final energy accounting approach. Overall useful energy demand does not decline (despite a temporary trend reversal between 2022 and 2035), contrary to final energy.

Figure 8: Transport energy consumption by type of energy in IEA's NZE scenario, considering a final and useful energy accounting approaches, and also singling out renewable energy



Source: same as Figure 5, adding details on renewable electricity, hydrogen and hydrogen-based fuels ("Other") from IEA, 2023 and also adding final to useful energy conversion factors based on average values in Table 1, historical shares of energy demand in road, aviation and shipping given – for the NZE scenario – in IEA, n.d. (until 2022), and considering also that most electricity and hydrogen would be used on inland transport modes.

Primary energy accounting, not shown due to the complexities related to different transformation pathways and data availability limitations, would increase by about 15% the historical shares of oil-based fuels (due to refining losses, oil being the main source of energy in refineries, and petroleum products being the main form of energy used in transport). Bioenergy demand would also increase, by 30-40% (due to conversion losses that are higher than those of other fuels, except for hydrogen derivatives, with the latter only considered at some scale after 2035, in this scenario). Smaller increases would occur for gas (due to its contribution to energy use in industrial, energy conversion and electricity generation facilities, combined with limited shares of biofuels and electricity in historical energy demand in transport).[10]

Table 4 reports quantitative values of sector-wide energy use goals for transport decarbonization as they can be derived from a final and useful energy accounting approach, based on the assessment shown in Figure 8. The Table shows consistency between the IEA Net Zero Roadmap and the energy demand and the sustainable biofuels and renewable sources references in the Declaration, despite small discrepancies.[11]

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[10] With a full life cycle accounting, natural gas would also come in as one of the feedstocks needed for fertilizer production, for biofuels.

[11] The renewable energy share, in particular, is slightly lower than those of low-carbon energy or the "green fuel" shares used in the work of Zhang-Billert and Welle, 2025, but still close to a third of the total.

Table 4: Sector-wide energy use goals for transport in 2035.

	2035 (vs. 2022 baseline)	
	Final energy	**Useful energy**
Total energy demand	-24%	7%
Green fuels	36%	53%
Low-emission energy	34%	48%
Renewable energy	31%	43%
Biofuels	14%	10%
Electricity	18%	39%
Low-emission electricity	16%	34%
Renewable electricity	14%	30%
Hydrogen and its derivatives	5%	5%
Low-emission hydrogen and its derivatives	4%	4%
Renewable hydrogen and its derivatives	3%	3%

Note: The percentages reflect the changes in the value between 2022 and 2035 for each line of the Table, in a way that is fully consistent with what is graphically shown in **Error! Reference source not found.**.

Source: same as **Error! Reference source not found.**

Sensitivity of the results to different technological developments, highlighting the centrality of road and rail transport electrification

Quantitative values of sector-wide goals for transport decarbonization are sensitive to variations in the contributions of different technologies. Figure 9 shows impacts on final energy demand developments due to partial achievement of technology shifts (towards biofuels, electrification and hydrogen and its derivatives) while useful energy demand remains unchanged. Figure 10 does so looking at shares of renewables in final energy demand. Figure 11**Error! Reference source not found.** does the same for the share in useful energy demand.

Results in Figure 9, Figure 10 and Figure 11 point to important considerations, showing that:

- The lack of a full achievement of the electrification transition (particularly compelling in road and rail transport) [12] has strong impacts on the underachievement of the targets.
- Cases where biofuel or hydrogen transitions are incomplete have less significant impacts on the underachievement of the targets.

Similarly, overachieving the electrification transition in transport would come with significant advantages, enabling additional savings in final energy demand and (with shares of generation from renewables that do not change vs. a scenario where transport electrification targets are not overachieved) higher renewable energy shares.

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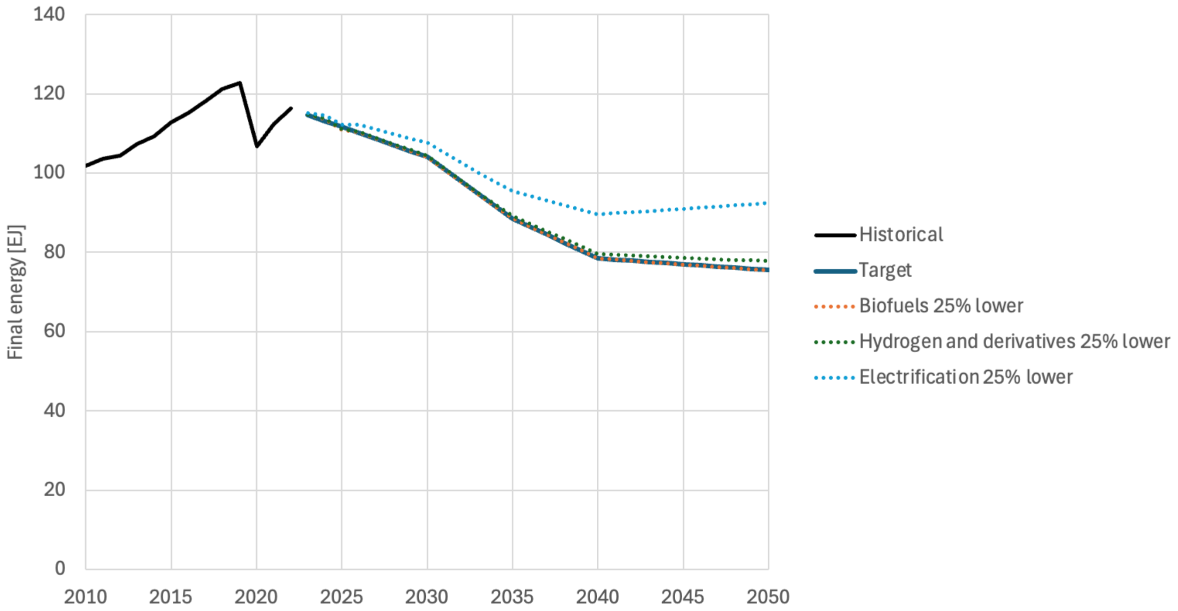
[12] Road and rail transport are the modes where direct electrification is most cost effective. Biofuels from sustainably produced feedstocks and/or low-carbon forms of hydrogen and its derivatives remain crucial in shipping and aviation, where there is a lower scope for electrification.

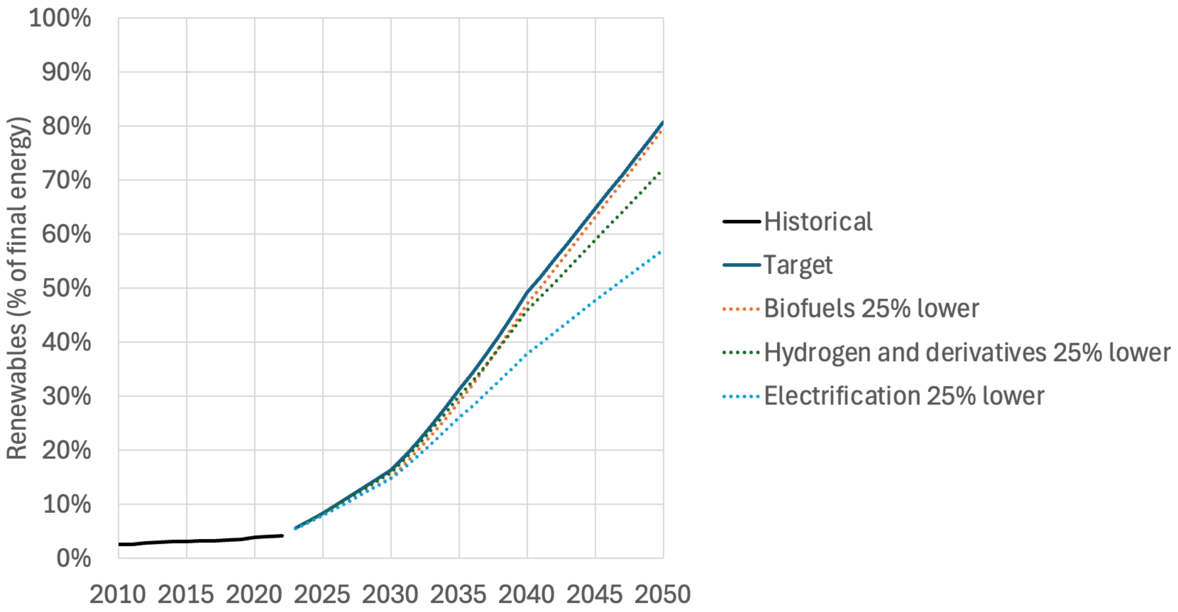
Figure 9: Sensitivity to the partial achievement of technology shifts for total final energy demand



Note: “25% lower” refers to cases characterised by a partial achievement of technology shifts (towards biofuels, electrification and hydrogen and its derivatives, while useful energy demand remains unchanged. Results are impacted by useful to final energy ratios and the relative importance of different forms of energy for the achievement of the target according to the IEA Net Zero pathway.

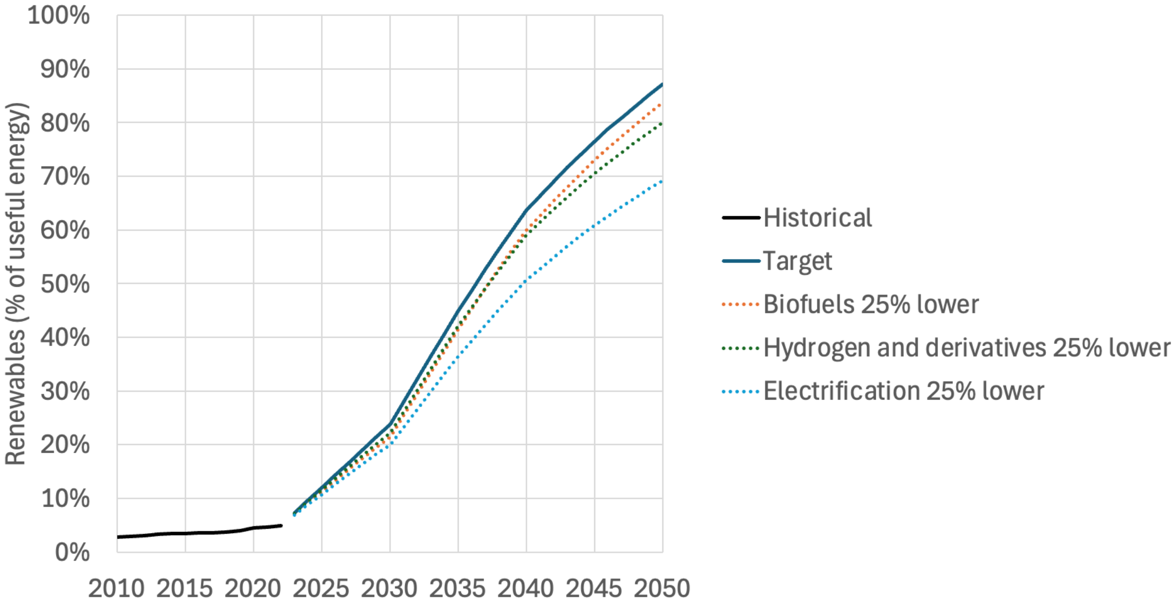
Source: this assessment.

Figure 10: Sensitivity to the partial achievement of technology shifts for the shares of renewables in final energy demand



Source: this assessment.

Figure 11: Sensitivity to the partial achievement of technology shifts for the shares of renewables in useful energy demand



Source: this assessment.

One additional element requiring specific consideration are the renewable shares of electricity generation in the assessment of the targets. This can be achieved taking an average accounting approach, based on the total share of renewable or low-emission electricity generated, even if there may well be cases when the electricity mix used in transport differs from the overall average (as the electricity generation mix varies over time). The reason for this is grounded primarily in data availability, as there are no available data sources for electricity shares delivered to transport vehicles, with global coverage, based on a marginal accounting approach.[13]

Importance of an authoritative and reliable source of international data

Tracking global developments does not only require a viable methodology, but also the availability of authoritative, transparent, regularly updated, highly visible and multilaterally vetted data sources, to guarantee reliability and to serve the key purpose of the indicator to track progress over time and provide timely insights for decision-making.

At the moment, a dataset that has the closest match with these features, while also enabling a reasonable degree of differentiation across energy products and some degree of differentiation across transport modes, is the World Energy Balances by the IEA (IEA, 2025).

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[13] It is relevant to recall, in this context, that managed charging is not only more economically attractive, but also well suited can enable EVs – which lie at the core of transport electrification – to become assets rather than liabilities (as in the case of unmanaged charging) for the electricity network. This means that there can be cases where the renewable electricity share used in transport may well exceed the average share of generation. The opposite may also be true, especially in cases where EV charging is less flexible and requiring higher power, even though these are also cases where investments in low-cost, low-emission electricity are also the most rational economic choice.

This dataset offers energy balances expressed in uniform units (thousand tonnes of oil equivalent, terajoules), along with conversion factors, indicators (GDP, population, industrial production), and notes on methodologies and sources. It is updated twice annually – April and July. The month of July also marks the release of the final edition, with global data. It covers 156 countries, with a global scope and a progressively broader geographic coverage, usually covering data up to two years prior to the current year.

To ensure coverage and harmonization at the global level, the IEA cooperates closely with regional and international partners such as Eurostat in Europe, the Latin American Energy Organization (OLADE), and other statistical bodies. This collaboration helps reduce duplication of reporting, align methodologies, and enhance data quality by integrating national submissions with regional energy data systems.

Few alternatives are available. Enerdata (a private consultancy), in particular, publishes annually (behind a subscription) data on energy and CO_2 emissions (Enerdata, 2025). This may have limitations in country coverage, it may not have same granularity (e.g. for smaller countries or trade flows), and it might also not cover all countries with full detail. In Germany, the Federal Institute for Geosciences and Natural Resources presents data and facts on the worldwide availability, production, import, export and aggregated demand of energy, including crude oil, natural gas, coal, uranium, geothermal, renewables and hydrogen, but not on demand by end-use sector (BGR, n.d.). The Statistical Review of World Energy (Energy Institute, formerly BP) also focuses on supply and does not have a sectoral breakdown on the demand-side comparable to the one available from IEA (Energy Institute, 2025).

Additional data, specific to fuels certified according to the internationally agreed CORSIA sustainability framework, are also released by ICAO in a dedicated tracker in mass units (ICAO, n.d.) and can be converted to energy data based on net heat of combustion as defined in ASTM technical standards for aviation fuels (42.8 MJ/kg). Similar frameworks are may also be developed as sustainability criteria are defined also for maritime transport, following ongoing work at the IMO.

Proposal for a pragmatic approach, balancing pros and cons

The tracking of a global effort to achieve a 25% reduction in total transport energy demand relative to 2022 levels by 2035 and an increase in the share of sustainable biofuels and renewable energy to at least one-third of total transport energy use needs to follow a pragmatic approach.

This should be trying to maximise opportunities for accuracy, fairness and meaningful contribution to support developments that are in sync with what the effort intends to promote. At the same time, it needs to take into due consideration the nature of different forms of energy, accounting methods used to track energy flows and considerations actually defining both sustainability (including related complexities and challenges) and renewable energy.

More specifically, the approach taken should consider:

- The challenges related to how to define sustainable energy, and in particular biofuels (something is subject to a complex set of assessment methods, including several that have strong dependency on the production pathway considered).
- The fact that these complexities are also affecting GHG emission and primary energy accounting assessments.
- The challenges for the development of an accounting approach based on primary energy, especially for biofuels, due to differences in primary/final energy ratios (that vary by pathway), also subject to data tracking-related limitations (as biofuels are not highly disaggregated based on detailed pathway specifications[14]).
- The necessity to acknowledge important differences in terms of final/useful energy ratios, especially for electric mobility, in road and rail. Failing to do so could significantly and unfairly underestimate the contribution of forms of electricity that have high primary/useful energy (reflecting accounting decisions specific to technologies like solar, wind and hydroelectricity) and final/useful energy ratios (reflecting high end-use energy efficiency), in terms of energy shares.
- The relevance of tracking electrification more closely for rail and road.
- The possibility to have visibility on the contribution of sustainable fuels for aviation and shipping – the sectors where they matter the most – in the total amount of biofuel supplies (and, going forward, also in other renewable fuel supplies).

The tracking proposed is therefore based on the following key indicators, using both a final energy and a useful energy accounting approach:

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[14] This is not only the case of the IEA balances, but also for other important references, such as the OECD/FAO agricultural outlook, which includes a chapter on biofuels, provided in recent editions more pathway disaggregation, but with limited country-level and transport sub-sector information (OECD/FAO, 2025).

- Overall global energy demand in transport and its evolution, benchmarking it against the 25% reduction with respect to a 2022 base year value considered in the Declaration.
- Shares of sustainable biofuels and renewable sources, considering that a 33% share (one third) of these (as foreseen in the Declaration) forms of final energy is equivalent to a 45% share in terms of useful energy (due to different final to useful energy ratios).
- The shares of electricity and renewable electricity in transport energy demand, taking an average accounting approach for the assessment of renewable electricity shares.
- The shares of aviation and (when available) shipping fuels that are certified as sustainable in internationally agreed frameworks out of the total of all renewable fuels used in transport.

The tracking of the shares of electricity and renewable electricity in transport is not only coherent with the key role of electrification to reach the objectives of the Declaration, but also aligned with the objectives of tripling renewables and doubling energy efficiency improvements developed in the context of the COP 28 GST and being promoted by the *Triple Up, Double Down, Electrify Now* that is currently being developed.

The separate tracking of aviation and shipping fuels that are certified as sustainable in internationally agreed frameworks is coherent with the fact that these are fuels used in sectors (long-distance aviation and shipping) where renewable fuels matter the most (due to challenges to electrify these sectors cost-effectively).

The pragmatic approach should also be grounded on internationally available and reliable data, regularly updated. Data sources that capable to support this pragmatic approach include:

- The IEA World Energy Balances dataset to track final energy data, including information on biofuels and the share of renewable electricity.[15] This would strengthen the focus on the need for a combined transition to transport electrification and renewable electricity generation.
- The use of ICAO data regarding aviation fuels certified as sustainable, with the option to also do so for shipping, following the development of IMO trackers, to help bridging the issue that these are not explicitly tracked in the IEA World Energy Balances.
- The complementary use of targeted and more aggregated data, based on specific sectorial publications and scientific literature to have a timely tracker, for the most recent years.

For the tracking of shares of sustainable biofuels and renewable sources, useful energy accounting should be calculated based on final energy data, complemented by fixed energy conversion factors, defined by flow (i.e. transport sub-sectors: road, rail,

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[15] Including bioenergy, renewable waste, geothermal, hydropower, solar, photovoltaics (PV), concentrating solar power (CSP), wind and marine (tide and wave) energy, as mentioned in the Declaration.

domestic and international aviation, domestic and international shipping) and product groups.

Product groups should be based on aggregations in the same group for final energy products that rely on the same type of energy conversion devices, i.e. spark ignition engines, compression ignition engines, electric motors and batteries in road transport, combustion engines and electric motors in rail, combustion-based technologies and alternatives reliant on electric motors and batteries in aviation and shipping), while remaining open to revisions if and when hydrogen and its derivatives gain relevance in the energy mix). Reference values should be sourced from Table 1.

Shares of useful energy for fuels should also be assessed based on the IEA product classification (e.g. gasoline, diesel, jet fuel, bio-gasoline, bio-diesel, bio-jet fuel) and their shares in final energy, as reported in the balances. This has the drawback of not relying on an agreed definition of sustainable biofuels (due to the complexity of this and the lack of a straightforward internationally agreed approach) and the advantage of tracking information on products that are currently the main alternative to liquid and gaseous petroleum-based fuels.

Electricity shares of useful energy should be calculated based on generation shares, as reported in the IEA balances. The same shares allow to track separately shares of renewable electricity. This has the advantage of avoiding issues related to the primary/final energy ratios assumed for different forms of electricity in the IEA balances (Table 3) and being consistent with the final energy accounting approach used for fuels by the IEA[16]. Aggregated updates to historical values can be based on emission trends from EDGAR, n.d. for fossil energy, EMBER, n.d. for renewable electricity shares, on OECD/FAO, 2025 for biofuels and biomethane, and on IEA, 2025c for hydrogen-related data. Same-year estimates may also become available from Global Carbon Budget, n.d. (although this is generally focused on economy-wide estimations).**Error! Reference source not found.** shows the result of this approach, overlaying data from updated historical values, up to the year 2024, to the data used to define the sectorial goals in Figure 5 and Figure 8. Despite efforts made, updated historical data already point towards a significant departure from the linear development considered for the 2022 to 2030 time period in the work developed by Zhang-Billert and Welle, 2025, especially for what concerns total energy demand. As described here in Figure 9, this underscores the importance to accelerate the global transition towards greater shares of electrification in transport, alongside other energy efficiency improvements.

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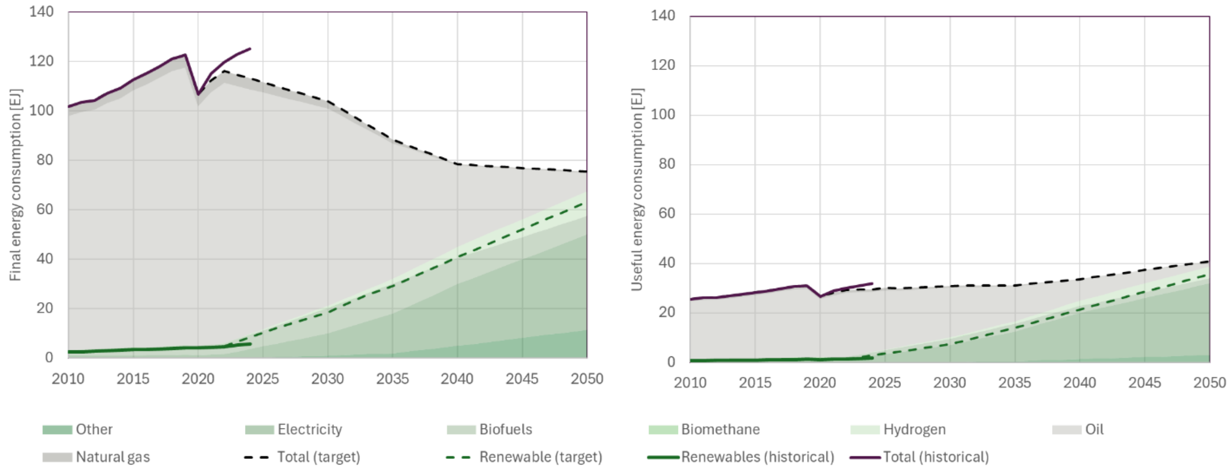
[16] The IEA balances can also give information on primary/final energy ratios, but in a far less trackable way, These ratios relate with energy losses occurring upstream of final energy accounting, since transport fuels are produced from other primary forms of energy (through chemical process, in refining, via anaerobic digestion, requiring hydrotreating and other fuel synthesis processes, and also in the production of intermediate products, such as fertilizers, for biofuels). An overview of primary to final energy ratios for key pathways is shown in Table 2. However, as discussed earlier, tracking them for the multiplicity of possible pathways would increase complexity and hit practical feasibility barriers, as international datasets, like the IEA energy balances, do not provide sufficient disaggregation.

Figure 12: Graphical results of the tracker regarding transport energy consumption by type of energy and renewable energy share, overlayed with targets and the wedges that informed them, considering a final and useful energy accounting approaches



Source: same as Figure 8, revising the renewable energy share target line based on the one-third value retained in the Declaration, adding updated historical data from IEA, n.d. to the latest available year (2023) and 2024 estimates based on EDGAR, 2025, OECD/FAO, 2025, IEA, 2025a, IEA, 2025b and IEA, 2025c.

Table 5 provides a numerical summary of the results shown in **Error! Reference source not found.**, solely focusing on total energy demand in transport and renewable energy shares (both as final and useful energy).

Table 5: Results of the tracker regarding transport energy consumption by type of energy and renewable energy shares

Year	**Final energy [EJ]**		**Final energy [EJ]**		**Useful energy [EJ]**	
	Total (historical)	**Total (trajectory towards the 2035 target)**	**Renewables (historical)**	**Renewable (trajectory towards the 2035 target)**	**Renewables (historical)**	**Renewable (trajectory towards the 2035 target)**
2022	119.8	116.2	4.7	4.8	1.4	1.4
2023	122.9	114.7	5.3	6.7	1.6	2.1
2024	125.2	113.1	5.7	8.5	1.8	2.8
2030		104		18.5		7.4
2035		88.5		29.2		14

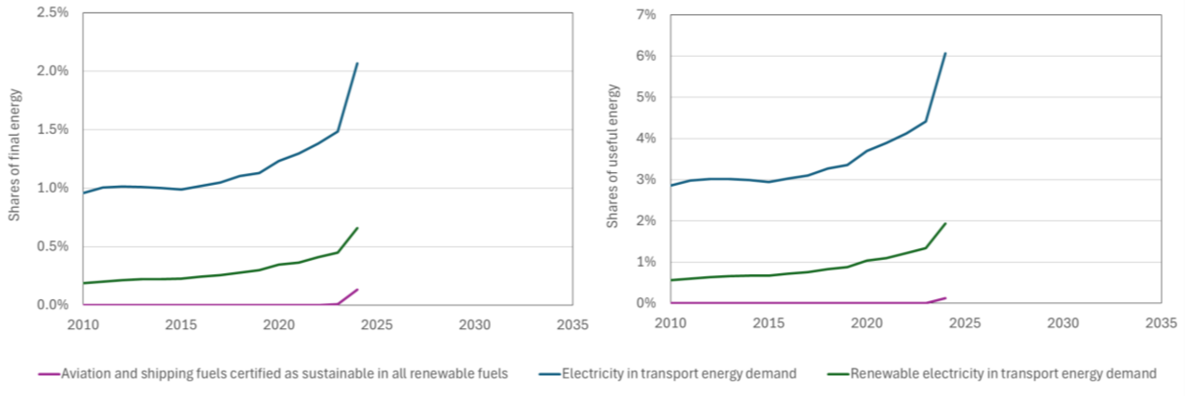
Note: the trajectories towards the target are those defined in Zhang-Billert and Welle, 2025, based on the IEA 2023 Net Zero roadmap.

Source: same as Figure 12.

Data regarding the final energy contained in aviation fuels certified as sustainable should be derived from the dedicated ICAO tracker (ICAO, n.d.). Data on the final energy contained in shipping fuels certified as sustainable will need to be sourced from the IMO once sustainability criteria are defined and once a tracker is developed. Data on the final energy demand of renewable fuels should be taken from the IEA energy balances. Their conversion of all these data to useful energy demand should be based on final energy data, complemented by fixed energy conversion factors, defined by flow (i.e. transport sub-sectors: road, rail, domestic and international aviation, domestic and international shipping) and product groups, as also outlined earlier.

Results of this approach regarding shares of electrification of energy demand in transport and of amounts that are derived from renewable electricity, as well as the shares of aviation and (when available) shipping fuels that are certified as sustainable in internationally agreed frameworks out of the total of all biofuels and renewable fuels used in transport are shown in Figure 13.

Figure 13: Results of the tracker regarding shares of electrification of energy demand in transport, shares of renewable electricity in all transport energy demand, and shares of aviation and shipping fuels certified as sustainable in the total of all renewable fuel use in transport, considering a final and useful energy accounting approaches.



Sources: same as **Error! Reference source not found.** with the complement of ICAO, n.d., as shipping data are currently still not available.

Comparative choices in other approaches

In this context, it is also important to notice that prominent international references have adopted a similar approach, integrating corrections related to differences in energy end-use efficiencies for the accurate accounting of renewable energy shares used in transport. Key examples include high-profile policy frameworks, such as Europe’s Renewable Energy Directive (via specific multipliers for renewable electricity supplied to road and rail transport), the Low Carbon Fuel Standard in California (United States) (via Energy Economy Ratios, EER) and similar corrections used in British Columbia (Canada), also in the context if its Low Carbon Fuel Standard. Further details on how each of these policies frameworks account for corrections related to differences in energy end-use efficiencies for the accurate accounting of renewable energy shares used in transport are included in Box 3.

Across these frameworks, a common methodological rationale emerges: energy carriers should be compared on the basis of useful transport service delivered rather than solely on gross energy content.

Box 3. How key policy frameworks account for differences in energy end-use efficiency for the calculation of the contribution of renewable energy in transport

As outlined in this document, accurate accounting of renewable energy shares in transport requires consideration of differences in end-use efficiency between energy carriers and vehicle technologies. Electric and other advanced drivetrains convert a higher proportion of input energy into useful motion than internal combustion engines. Different forms of energy are also subject to different accounting methods when considering primary and final energy. Without appropriate corrections, the share of renewable energy used on drivetrains that convert a higher proportion of input energy into useful motion risks to be understated.

The **European Union's Renewable Energy Directive** (RED and its recast iterations) incorporates several corrections linked to energy conversion and end-use efficiencies for its accounting framework for renewable energy in transport. Renewable electricity used in road transport is subject to a factor 4 multiplier when calculating renewable energy (European Union, 2018, European Union, 2023).[17] These multipliers are designed to reflect the significantly higher end-use efficiency of electric drivetrains relative to internal combustion engine vehicles, thereby aligning energy accounting with useful energy delivered for mobility. The RED framework also distinguishes between renewable electricity supplied directly to vehicles and renewable fuels of non-biological origin, accounting for conversion efficiencies in fuel production pathways (e.g., power-to-hydrogen, power-to-liquids). Multipliers and pathway-specific accounting rules aim to approximate differences in both primary-to-final energy conversion and end-use efficiency, ensuring that renewable electricity's contribution to transport decarbonisation is not understated when compared with combustion fuels.

California's Low Carbon Fuel Standard (LCFS) incorporates explicit corrections for end-use efficiency through the use of Energy Economy Ratios (EERs). EERs adjust the crediting of alternative fuels relative to a gasoline or diesel baseline by accounting for differences in vehicle efficiency and drivetrain performance. Electricity used in battery electric vehicles receives a substantially higher EER than liquid biofuels used in combustion engines, reflecting the superior tank-to-wheel efficiency of electric propulsion. Hydrogen used in fuel-cell vehicles is likewise assigned an EER that captures its higher conversion efficiency relative to conventional fuels. EERs are set to 3.4 for electric cars, 5 for heavy electric trucks and buses, 2.5 for fuel cell cars, and 1.9 for fuel cell heavy vehicles (Murphy, 2020)

Under the LCFS crediting system, fuel providers generate credits based on the carbon intensity reduction achieved relative to a fossil baseline, multiplied by the energy supplied and the applicable EER. By integrating EERs into the credit calculation, the LCFS ensures that fuels delivering more useful transport service per unit of final energy receive proportionately higher credit. This prevents systematic undervaluation of electricity and other high-efficiency energy carriers and aligns credit generation with real-world displacement of fossil fuel use. The LCFS also embeds lifecycle assessment of fuel pathways, which enables a consistent comparison across fuels with very different primary-to-final energy conversion efficiencies and end-use performance characteristics.

British Columbia's Low Carbon Fuel Standard (BC-LCFS) adopts a similar approach to California's system, including the application of EERs to account for differences in end-use efficiency across transport energy carriers. Electricity, hydrogen, and certain advanced fuels are credited using EERs that reflect their relative efficiency in delivering mobility compared with gasoline or diesel. As in California, these ratios are applied in the calculation of compliance units (credits), ensuring that fuels with higher end-use efficiency generate more credits per unit of delivered energy. The BC-LCFS also incorporates lifecycle carbon intensity assessment for each fuel pathway, accounting for upstream energy conversion processes from primary energy sources to final transport fuels.

Together, these approaches illustrate how policy frameworks can incorporate corrections for both end-use efficiency and primary-to-final energy conversion efficiency to ensure that renewable energy shares in transport are represented accurately.

Limitations and need for periodical revisions

Final to useful energy factors should also be updated in periodical methodological revision sessions (e.g. every 5 years) to ensure that they are in continuous alignment with available evidence. This periodical methodological updates would also help improving the tracker and expand it in terms of scope of the options that are covers, integrating adaptations to the product and flow structure of the energy statistics and balances of the IEA (and regional organizations that cooperate with the IEA), as these get modified when new energy flows and conversion processes gain relevance and scale.

Better tracking of hydrogen and hydrogen derivatives in the IEA balance is clearly an area requiring improvements, as these are not currently considered in dedicated products and flows.

Further improvements should ensure that sustainably produced biofuels and different types of hydrogen and its derivatives (similarly to what can already be done for electricity) are effectively integrated in the accounting method and in the goals. Not doing so risks misaligning the tracking of progress associated with the sector-specific goals suggested by Zhang-Billert and Welle, 2025 (based on the IEA Net Zero Roadmap) and incentives to develop solutions that can support both energy efficiency and GHG emission reductions. The tracking of the shares of aviation and (if and when they will become available) shipping fuels that are certified as sustainable in internationally agreed frameworks out of the total of all renewable fuels used in transport, using both ICAO and IEA data, partly addresses this issue. Evolutions in data availability for shipping and the possible harmonisation across national sustainability frameworks for land transport are key areas to consider for improvements.

Adding more details on which biofuels and which types of hydrogen are fit for purpose can attempt to leverage reports focused different biofuel production pathways and on hydrogen.

- For biofuels, the focus should be placed on a better differentiation of pathways reliant on sustainably produced feedstocks. In addition to the ICAO and the possible IMO reporting on fuels falling under internationally-agreed sustainability frameworks, this can leverage data from the OECD/FAO agricultural outlook, the annual updated of the IEA market report on renewables and improvements in the IEA energy balance data, if and when they evolve in a way capable to enable an increased granularity regarding the alignment of different biofuel supplies with sustainability requirements.
- Shares of hydrogen from renewable energy or low-emission sources (and its derivatives) can also be tracked based on updates of annual progress reports, in particular the annual IEA hydrogen review (IEA, 2025c), unless they are discontinued.

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[17] For electricity used in rail, where electrification is already widespread and highly efficient, renewable electricity is credited directly based on measured consumption.

Conclusion

This report proposes a pragmatic and scientifically robust framework to track global progress towards the 2035 objectives outlined in the Declaration of reducing transport energy demand by one quarter and increasing the share of sustainable biofuels and renewable energy to one third of total transport energy use.

By combining final and useful energy indicators, relying primarily on internationally recognised data sources such as the IEA World Energy Balances, and complementing them with targeted sectoral information, the proposed approach enables credible and comparable monitoring of progress across regions, modes and energy types.

The suggested methodology balances analytical rigour with feasibility and timeliness. It recognises current data limitations and definitional challenges – particularly regarding sustainable fuels and emerging energy carriers – while offering a transparent framework that can evolve as statistical systems and international sustainability criteria improve. Periodic methodological reviews and refinements will be essential to ensure continued relevance and robustness.

To support transparency, accountability and policy relevance, it is recommended that a short global progress report be prepared and published annually, ideally each September following the release of the latest IEA data.

This report should track the following key indicators, using both a final energy and a useful energy accounting approach:

- Overall global energy demand in transport and its evolution, benchmarking it against the 25% reduction with respect to a 2022 base year value considered in the Declaration.
- Shares of sustainable biofuels and renewable sources, considering that a 33% share (one third) of these (as foreseen in the Declaration) forms of final energy is equivalent to a 45% share in terms of useful energy (due to different final to useful energy ratios.
- The shares of electricity and renewable electricity in transport energy demand, due to the key role of electrification to reach the objectives of the Declaration, taking an average accounting approach for the assessment of renewable electricity shares.
- The shares of aviation and (when available) shipping fuels that are certified as sustainable in internationally agreed frameworks out of the total of all renewable fuels used in transport, to track biofuels that are certified according to internationally agreed sustainability frameworks and used in sectors that where renewable fuels matter the most, in the total of all renewable fuel use in transport.

The assessment should also draw on the methodology and data sources to provide an authoritative and timely assessment of global trends. Regular publication will help inform international dialogue, support preparation for future UNFCCC GST, and maintain momentum toward achieving the shared goals of cleaner, more energy-efficient and resilient transport systems by 2035.

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