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Reforming EU Car Labels: How To Achieve Consumer-Friendly Transparency?*

Nikolai Badenhoop†, Max Riedel†

Abstract

We examine the EU car labelling regime for CO_2 emissions and fuel efficiency under Directive 1999/94/EC and document strongly diverging national labelling methodologies. Our contribution is fourfold. First, we distil the most relevant economic and behavioural research findings on car labelling. Labels effectively help consumers make informed decisions if they are well-designed, comprehensible, and informative about hidden costs. Second, we compare the national car labelling methodologies and find stark inconsistencies, undermining the EU's effort to decarbonise the car sector. Empirically, we find heterogeneous distributions of the national labels if applied to the national and EU car fleets. Third, we assess the EU energy efficiency labelling regime for electric appliances under Regulation (EU) 2017/1369 as a labelling role model. Finally, we propose a standardised EU car label with comparative information in two distinct coloured scales using absolute labelling thresholds for CO_2 emissions and fuel or energy efficiency.

KEYWORDS

Car labels, CO2 emissions, Energy efficiency, Fuel economy, Directive 1999/94/EC, Passenger cars, Sustainable transport

JEL CLASSIFICATION R4, K300, K320, L920, L980, Q480, Q580

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1 Introduction

Climate change poses a substantial challenge and an existential threat to humanity, making it a key issue of our time. In response, the European Union (EU) has enacted a suite of policies designed to mitigate environmental impacts and propel the economy towards climate neutrality by 2050 (European Climate Law).[1] A critical focus of these initiatives is the transport sector, which accounts for nearly one-quarter of Europe's greenhouse gas (GHG) emissions (European Commission, 2021) and is a major contributor to climate change. The EU builds its decarbonisation strategy for passenger vehicles on three main pillars. First, it mandates car manufacturers to lower the CO_2 emissions of the cars they sell in the EU. In particular, the manufacturers must gradually reduce their cars' fleet-wide CO_2 emissions to reach 0 gCO_2/km from 2035 onwards.[2] Second, the EU has legislated a CO_2 emissions trading system to cover transport from 2027 onwards.[3] This will result in additional CO_2 prices for fossil fuels and raise the financial advantages of CO_2 -neutral vehicles for consumers. Third, the EU seeks to nudge consumer behaviour into purchasing vehicles with lower CO_2 emissions by using car labels as informational tools, which are the main focus of this paper.

Car labels are mandated under Directive 1999/94/EC, which stipulates that the labels must at least display information regarding a car's combined CO_2 emissions and fuel economy (*basic label*).[4] However, some Member States went beyond these requirements in their national implementations. They have introduced a colour-coded scale on the labels, which compares a vehicle's CO_2 emissions or fuel economy across different market segments (*coloured label*). We show that the methodologies for this comparison vary substantially across countries. Therefore, we propose in this study to reform the EU car labelling regime by introducing a standardised, EU-wide car label with two coloured rating scales: one for CO_2 emissions and one for fuel efficiency. Each scale would use absolute rating thresholds. There are two primary reasons for adopting this dual-scale approach. First, they address two different EU policy goals and

[1] Regulation (EU) 2021/1119.

[2] Annex II Part A Commission Implementing Decision (EU) 2023/1623 and Article 1 (5a)(a) Regulation (EU) 2019/631.

[3] Directive 2003/87/EC as amended by Directive (EU) 2023/959 and Regulation (EU) 2024/795.

[4] Throughout this study, we refer to fuel economy or efficiency by subsuming both fossil fuel and electricity consumption of vehicles.

aspects that matter to consumers. A coloured label for CO_2 emissions directly supports the EU's decarbonisation goals, while a separate coloured label for fuel or energy efficiency raises awareness on the respective energy intensity. Second, the energy efficiency aspect is currently missing in countries with CO_2 -based coloured labels assigning all electric vehicles to category A, regardless of their electricity consumption per km. A separate coloured label for fuel efficiency would thus offer a more nuanced assessment of a vehicles' combined environmental and energy impact. A mirrored problem arises for countries whose coloured labels currently focus only on fuel efficiency. Third, once the EU achieves its decarbonisation targets, the focus will shift towards improving fuel efficiency, rendering the CO_2 -based label obsolete in the long run. Therefore, the dual-scale approach is a temporary solution and might prove a helpful information tool for the transition towards decarbonisation and energy-saving.

In the following sections, we analyse the current car labelling regime in the EU against the backdrop of economic and behavioural research findings. We then explore the legal implications of implementing a standardised label across the EU and propose a potential design of new car labelling framework.

2 Related literature

2.1 Eco-labels and energy labels as a tool for steering markets

Research suggests that European consumers pay attention to energy labels and eco-labels when making product choices. In fact, most consumers in Germany, Great Britain, Ireland, and Italy were found to have shown interest in eco-labels (Thøgersen, 2000). This consumer attention seems to translate into higher sales figures for better-performing products: Stadelmann & Schubert (2018) found that using EU energy labels increased online sales of energy-efficient appliances. Further, eco-labels were shown to have positively affected sales of high-efficiency appliances and their market share in the EU. For example, the increased transparency on the energy efficiency of cold appliances (i.e., freezers, refrigerators) under the EU energy labels was found to have increased the sales of high-efficiency products in the Danish market (Bjerregaard & Møller, 2019). Schleich et al. (2021) found that the combination of minimum energy performance

standards and energy labels has increased the market share of cold appliances with A+ or better labels in the EU. In conclusion, eco-labels seem to influence consumer preferences and decision-making, emphasising the need for their effective design.

2.2 Designing labels according to consumers' needs

The extent to which a consumer responds to a label depends on how the information is being presented. Research in social psychology and experimental economics has identified various design features of labels that can impact consumers' decision-making process. These features can trigger consumer attention, raise awareness, affect unconscious reactions, and even reduce the cognitive effort required to process information (Hille et al., 2018).

2.2.1 Comparative labels

Labels with a letter ranking, such as letters A to G, allow consumers to compare products by providing a coarse summary of more detailed and accurate information. This so-called comparative label facilitates product differentiation and guides consumers towards higher-ranked products (d'Adda et al., 2022; Sammer & Wüstenhagen, 2006; Newell & Siikamäki, 2014). The length of the scale seems to play a crucial role since shorter scales enhance consumers' perceptions of the different label categories and, therefore, positively affect their choices. This was demonstrated in an experimental study by Waechter et al. (2016). Moreover, adding new classes (A+++, A++, etc.) to the A-G rating scale undermined the effectiveness of EU energy labels and might have contributed to market failure (Heinzle & Wüstenhagen, 2012). Also, colour impacts decision-making: Colour-coded labels convey factual information in a user-friendly manner, with the colours green and red serving as positive and warning signals, respectively (Hille et al., 2018). Further design features include monetary and health-related information, both improving consumer decisions if framed properly. For instance, health-based information framing strategies led to persistent energy savings behaviour (Asensio & Delmas, 2016). Another aspect is the target group. Experimental research has shown that the EU energy label is more effective than detailed information on annual energy use vis-à-vis consumers with low cognitive reflection, while the opposite holds true for consumers with a high level of cognitive reflection (Andor,

Frondel, et al., 2019). More generally, there is evidence that consumers might misunderstand labels with coarse information signals, rendering them ineffective. Darden & McCarthy (2015) find that introducing a rating program for health plans did not drive beneficiaries toward the highest-rated plans meaningfully.

2.2.2 Running and lifetime costs

In the context of EU energy efficiency labels, monetary information on energy consumption was found to facilitate consumer understanding of the technical data reported (de Ayala & Solà, 2022). In particular, lifetime-cost information increases consumer demand for energy-efficient appliances (Andor, Gerster, & Götte, 2019). Some scholars have proposed using a "10-year energy cost" label as an effective approach to increase energy-efficient choices (Hardisty et al., 2020). Also, for car labels, monetary information seems to play a crucial role for consumers. Studies show that labels are most effective if accompanied by fuel cost or future fuel-saving information. Information processing seems to work best with labels based on fuel economy, while labels based on CO_2 emissions are more effective if linked to future fuel-saving information (Codagnone et al., 2016). Other findings suggest that fuel cost labels tend to increase consumers' willingness to pay for higher fuel efficiency than labels based on fuel consumption (Brazil et al., 2019; Camilleri & Larrick, 2014). Also, information on tax savings and annual costs seems to positively impact consumers' vehicle choices according to surveys with participants from Germany, Ireland, Italy, the Netherlands, Spain, the UK, the Czech Republic, and Lithuania (Folkvord et al., 2020).

2.3 Distortionary effects and consumer confusion

Depending on the design, labels can have distortionary effects and produce consumer confusion. Given that a label acts as a substitute for more detailed information, consumers may misperceive the information signal stemming from it (Houde, 2018). In the US context, consumers are confused by the miles per gallon (mpg) measure because they wrongly think that fuel costs scale linearly (Allcott, 2013; Larrick & Soll, 2008). The same cognitive bias applies to the km per litre measure of fuel economy (Tanaka et al., 2021). Consumer confusion can arise due to uncertainty about the exact quality standard the label intends to signal (Harbaugh et al., 2011). For car

labels, experimental research finds that colour-coded labels dominate consumers' information processing, with colour increasing the salience of specific pieces of information (Hille et al., 2018). However, the relative rating approach can generate investor confusion. When a colour code and a relative rating are combined, consumer perception regarding a car's overall environmental performance can be misled. This was one of the major criticisms of the former German car label that used a relative approach relating a car's emissions to its weight, thereby giving preferential treatment to heavier cars (Bund für Umwelt und Naturschutz Deutschland, 2018; *Bundesrat Drucksache 657/23*, 2023). Experiments found that switching from absolute to relative ratings leads consumers to perceive vehicles with high CO_2 emissions as more environmentally friendly than vehicles with low emissions levels due to various effects, such as colour priming and increased salience (Hille et al., 2018). Therefore, the absolute rating approach seems to be more direct and informative regarding a vehicle's environmental performance, avoiding consumer misperceptions. However, although car labels influence consumer choices towards eco-friendlier cars, consumers seem unable to process the entire A to G rating scale, as researchers have found a price premium only for A-rated vehicles (Alberini et al., 2016). Thus, an optimal rating scale length has yet to be determined.

2.4 Price effects and welfare impact

Product labels serve as tools that can either complement or substitute traditional regulatory instruments, such as minimum quality standards and taxation, to influence consumer behaviour and market dynamics (Golan et al., 2001). They have the potential to be reflected in price premia and impact various stakeholders.

2.4.1 Eco-labels and energy labels

Studies have shown that eco-labels and those promoting a low carbon footprint impact the pricing of products, with consumers willing to pay a significant price premium for such products. For instance, consumers were found to have a high willingness to pay for organic conversion-grade food in five EU countries (Tranter et al., 2009), for non-food agricultural products (Michaud et al., 2013), organic cotton in sportswear (Casadesus-Masanell et al., 2009), energy-efficient

dishwashers (Galarraga et al., 2011), and A- and B-labelled vehicles in Spain (Galarraga et al., 2014). Moreover, labels that disclose CO_2 emissions have been shown to enhance consumer welfare by enabling more informed choices (Caputo et al., 2013). This is further supported by the existence of energy efficiency labels, which stimulate competition among manufacturers, pushing them to innovate and produce higher-rated products (Mahlia, 2004). However, the efficacy of environmental labelling is not without challenges. There is evidence that labels that signal the carbon intensity of a product can dilute the effectiveness of other environmental labels (Onozaka & McFadden, 2011). Furthermore, firms offering products of the highest environmental quality may suffer due to consumer confusion (Section 2.3). In addition, those producing lower environmental quality products can gain a competitive edge by offering a lower price than the most eco-friendly options (Brécard, 2014). Eventually, the complexity and proliferation of eco-labels may reduce their efficiency by overwhelming consumers rather than guiding them (Yokessa & Marette, 2019).

2.4.2 Car labels

In the context of vehicles, car labels have tangible impacts on the market. They influence pricing, as consumers seem to consider these labels when purchasing. This can drive demand for more energy-efficient or low-emission vehicles (Section 2.1). However, this demand can lead manufacturers to increase prices. For instance, a 6-11% price jump was documented in Switzerland for cars that qualify for an A rating (Alberini et al., 2016). Even though this is a considerable cost for consumers, car labels detailing CO_2 emissions and energy consumption can better inform purchases of low-emission vehicles, potentially contributing to cleaner air in urban areas in the long run. Clean air can lead to health benefits (WHO, 2013), increased workforce productivity, and lower medical costs for society as a whole. Studies have demonstrated a significant improvement in air quality due to the use of low-emission vehicles in China (Liang et al., 2019), Italy (Ferrero et al., 2016), Spain (Soret et al., 2014), and the United States (Filigrana et al., 2022; Tessum et al., 2014). Research on the causal relationship between the introduction of car labels and air quality improvement remains yet to be conducted.

3 Regulatory fragmentation of European car labels

3.1 Methodologies for car labelling

With the introduction of Directive 1999/94/EC, the EU has left ample room for defining car labels at the national level. The methodologies employed in national car labelling standards can be differentiated according to three categories: (a) the use of absolute versus relative values, (b) reporting of fuel consumption versus CO_2 emissions, and (c) the application of colour coding versus plain numerical values. Each method has its own merits and offers consumers specific insights into the environmental impact of their vehicle choices. Table 1 provides an overview of the definitions used for the car label in all EU Member States.

[Table 1 about here]

3.1.1 Colour-coding vs. plain numerical value

The first striking observation in Table 1 is that there is a high heterogeneity across countries regarding how the CO_2 emissions and the fuel consumption information of passenger cars are presented to the consumer.[5] While all countries require the manufacturer to inform consumers about the vehicle's actual fuel economy and CO_2 emissions (i.e., basic label), only ten countries also require a coloured label that typically has seven categories, going from A to G. Yet the number of categories is not harmonised and ranges from seven (majority of countries) to ten categories (Denmark: A+++ to G), with Austria being an outlier using a continuous scale. Also, the colours are not aligned across the countries: Most jurisdictions rely on the green-yellow-red colour coding to signal the vehicle's "greenness" regarding emissions or fuel consumption. In addition to these, Belgium employs the colour blue for zero-emissions vehicles. In Denmark, the colour scale is shifted, with A+++ being dark green, B being light orange and the categories D to G being assigned the colour red.

Although a basic label informs prospective buyers about the vehicle's emissions and fuel

[5] A further layer of heterogeneity stems from the differentiation between fuel types. For instance, in Denmark, the labelling thresholds differ for petrol and diesel vehicles, while Spain employs different calculation methodologies for the two fuel types. For ease of comparison, Table 1 only reports the thresholds for petrol-powered vehicles.

efficiency, it may not adequately convey the vehicle's environmental impact in relation to targeted regulatory CO_2 emissions or fuel economy standards. A coloured label proves more informative as it provides a scale and denotes the vehicle's position on it.

3.1.2 Absolute vs. relative values

Table 1 indicates a strong division among countries regarding the thresholds used for determining the car label categories. Six countries have chosen to use absolute values, while four countries have adopted relative values for their classifications.

Among the countries using absolute values, the majority links the label to average emissions of CO_2 in grams per km (Austria, Belgium, Germany, Estonia, France), while Denmark focuses on fuel consumption in km/litre. The absolute values are part of the vehicle's technical specifications, making them straightforward to obtain and compare across different vehicles.

In contrast, relative values rely on country-specific methodologies that may differ significantly, particularly concerning the input variables they use. For example, Spain calculates a reference value for average fuel consumption based on the vehicle's length and width, along with two estimated parameters. A vehicle's label is then assigned based on how it compares to this reference value for vehicles with the same surface area. Bulgaria employs a simpler method by basing the label on the car's CO_2 emissions relative to the average CO_2 emissions of new passenger cars registered in the EU the previous year, with the current reference value set at 153 gCO_2/km. Generally, the process for determining relative labels lacks transparency in many of the countries that use this approach. In Spain, the decree provides no explanation of the estimation procedure of the two input parameters. Similarly, the Dutch decree does not specify any methodology but instead refers to the Ministry of Infrastructure and the Environment for further details. In Portugal, the methodology for defining the lowest and highest fuel-consuming vehicles is unclear, and it does not establish clear thresholds for the car classification.

In conclusion, using absolute values in coloured labels offers greater transparency and reduces consumer confusion regarding the criteria used for the classification. This aligns with the scientific evidence presented in Section 2.3.

3.1.3 Fuel consumption vs. CO_2 emissions

Six out of ten Member States adopting a coloured label prefer to inform consumers about the vehicle's direct CO_2 emissions. This approach automatically places EVs in the highest label class as they do not directly produce CO_2 emissions. The national labels disregard the CO_2 emissions that can occur while generating electricity, e.g., in coal or gas power plants. Conversely, the four jurisdictions that have adopted fuel consumption as a reference value provide car labels solely for petrol and diesel vehicles. In these countries, electric, gas, and hydrogen vehicles do not receive a coloured label, which may indicate a regulatory bias against these types of vehicles.

3.2 One vehicle, many labels

One of the EU's main goals is to create a single market for goods to set, among others, high safety standards for protecting the environment.[6] There is still a long way ahead to achieving this goal, as illustrated by the many different car labels being assigned to the same vehicle in the EU.

According to Table 1, the thresholds for the colour-coded categories and their bin width vary considerably across countries. For instance, category A is reserved only for vehicles emitting 0 gCO_2/km in Germany, while in France, vehicles eligible for the same category are allowed to emit up to 100 gCO_2/km. In contrast, a car emitting 100 gCO_2/km would receive a two-notches lower category C label in Germany and Belgium. In Austria, it would receive a yellow-coloured label, typically associated with the category D label in countries that apply letter grading. At the lower end, a car with 176 gCO_2/km would receive G in Germany, F in Belgium and Estonia, and E in Bulgaria and France. Notably, under the relative rating approach, the average vehicle has a D rating in Bulgaria and Estonia, while the Netherlands reveal an upward bias by placing it in category C. Conversely, assuming that the average vehicle registered in the EU emits 153 gCO_2/km (reference value for the Bulgarian relative rating), Belgium, Germany and Estonia would place it in category E, while France would assign it to category D. These divergences across countries might be partially attributed to a change in methodology for measuring the

[6] European Commission, Guide on Articles 34-36 of the Treaty on the Functioning of the European Union (TFEU).

fuel consumption and CO_2 emissions that occurred in 2017 when the EU replaced the old New European Driving Cycle (NEDC) lab test by the stricter Worldwide Harmonised Light Vehicle Test Procedure (WLTP) for the type-approval of cars (JRC, 2017).[7] However, this cannot be the sole explanation since this change should not affect the relative rating approach. Also, the existing absolute standards cannot be grouped into two consistent (NEDC- and WLTP-based) categories but instead follow six divergent approaches.

Figure 1 illustrates the dispersion of the labels for one of the most popular sports utility vehicles (SUV) sold in the EU, a Volkswagen T-Roc.[8] We can observe that the SUV's label is assigned category B in Denmark (fifth out of ten categories, orange colour), C in France, Spain, Bulgaria and the Netherlands, D in Belgium and Estonia, E in Germany, and no letter in Austria (light orange colour, equivalent to E) . In addition, in most countries (indicated in dark grey), consumers only have access to information about the vehicle's actual fuel consumption and the CO_2 emissions without a clear, immediate indicator of the vehicle's overall environmental impact.

[Figure 1 about here]

In countries that have adopted a coloured label, this information is provided at the vehicle's physical point of sale. National regulations typically do not account for prospective buyers often gathering information about vehicles via a pre-purchase online search. Coming from times of low household internet penetration, Directive 1999/94/EC does not prescribe car labels in online advertisements. Therefore, customers find car labels for new cars in online marketplaces only in some countries, notably Spain. New vehicles in other EU countries can but do not have to be accompanied by a car label in such online offers.[9] As a result, the online use of car labels is fragmented both across and within EU borders. Currently, European consumers face inconsistent car labels across borders and are exposed to insufficient label transparency in online vehicle marketplaces within the individual countries.

[7] Commission Regulation (EU) 2017/1151.

[8] In 2022, Volkswagen's T-Roc was the third best-selling car in Europe according to Statista (https://www.statista.com/statistics/1127929/best-selling-car-models-in-europe-by-units-sold).

[9] Based on search for the SUV's car label on the following online marketplaces: autoscout24.at, gocar.be, mobile.de, bilbasen.dk, lacentrale.fr, autoscout24.nl, auto.ria.com

4 Empirical fragmentation of European car labels

4.1 CO_2 emissions and fuel efficiency of new cars registered in the EU

We base our analyses on data from the European Environment Agency (EEA), which holds a repository of all new passenger car registrations in the EU and collects information such as vehicle type, weight, CO_2 emissions, and fuel or energy efficiency (see Appendix A for further details on the data). Figure 3 illustrates the empirical fuel efficiency (Panels A to C) and CO_2 emissions (Panel D) for unique vehicle models registered in the EU in 2023. A unique vehicle model is defined as a unique combination of the vehicle's "type", "variant", "version", and "type approval number". These include all models of new passenger cars registered in 2023. We choose unique vehicle models instead of actual registrations to illustrate the full spectrum of cars consumers can purchase. This approach eliminates any distortions from consumer demand and focuses on the supply side of car models offered on the EU market. Panels A and B report fuel economy for ICEVs and PHEVs. Panel C depicts the distribution of electric energy consumption of PHEVs and EVs. Panel D plots the CO_2 emissions of ICEVs and PHEVs. It does not include EVs as they do not directly emit CO_2.

[Figure 3 about here]

A first striking observation is that nearly all distributions depicted in Figure 3 are right-skewed, suggesting that each engine type is associated with a long tail of less fuel-efficient or high-emitting vehicle models. Notably, EVs, which are always rated A in countries with CO_2 -based car labels, vary considerably regarding electricity consumption (Panel C). This highlights the need for distinguishing between high and low energy-consuming EVs. Additionally, Panel D shows that it is primarily EVs and PHEVs that achieve or are below the EU's emissions target of 115.1 gCO_2/km for 2020-2024, while most ICEVs miss this target. A year-by-year analysis for the period 2018-2023 indicates a positive trend, with the average CO_2 emissions being generally lower for newer ICEVs (see Appendix, Figure A1, Panels A and B). However, there is still room for improvement in both future fuel and energy efficiency, as well as CO_2 emissions across the whole EU car fleet.

4.2 Car label distributions for EU and national car fleets

A look at empirical data of car registrations in the EU highlights the stark inconsistencies of national car labels. We use the absolute rating thresholds for CO_2 emissions from Table 1 and assign the different national car labels to each vehicle registered between 2021 and 2023.[10]

[Figure 2 about here]

Figure 2 presents the car label distributions of the national (dashed line) and the EU-wide car fleet (solid line) under the rating methodologies of the six countries with CO_2 -based ratings. We observe that if the Austrian (Panel A) or German (Panel F) labelling methodology were applied across the EU, the majority of vehicles would be assigned a D-rating or worse. The Belgian methodology (Panel B) seems to be quite balanced, while the Bulgarian (Panel C), Estonian (Panel D), and the French (Panel E) labels are less penalising, with the majority of vehicles having a C-rating or better. The old German labelling methodology was similarly lenient (Panel F, long-dashed grey line), before it switched from a relative to an absolute rating approach in 2024.[11] The French methodology seems to favour in particular its national car fleet, as indicated by the larger share of A- to C-rated vehicles compared to the European average. The higher proportion of F- and G-rated vehicles in the national fleets Austria, Bulgaria, Estonia, and Germany suggests that consumers in these countries are more inclined to purchase vehicles with higher CO_2 emissions compared to the European average. These discrepancies highlight the need for a standardised European car labelling approach.

5 Negative effects of fragmented car labels

5.1 Regulatory capture at the national level

Leaving the modalities and methodologies of car labelling to national legislators runs the risk of fostering regulatory capture. Regulatory capture describes the phenomenon of "subversion of

[10] The car labels for fuel economy use predominantly relative thresholds, which are based on intransparent and complex rating methodologies. We therefore abstain from running the same exercise for these labels.

[11] Pkw-EnVKV 2024.

regulatory agencies by the firms they regulate" (Posner, 2013). It results in regulators promoting the interests of industries instead of taming them (e.g., the car industry dominating the process that is supposed to regulate it). On some occasions, Member States have been found to create rules that deliberately privilege their national industries against foreign competitors. The former German car label of 2011 provides an illustrious example (Pkw-EnVKV 2011). In addition to the absolute emission values of gCO_2/km and fuel consumption in l/100 km, it contained a coloured label on "CO_2 efficiency" with eight scales from A+ to G. It adopted a relative labelling approach relating the CO_2 emissions to the car's weight and treated heavier cars preferentially. Given that German car manufacturers produce, on average, heavier cars with a particular focus on SUVs (Keil & Steinberger, 2024), this regime treated them preferentially against EU competitors. The preferential treatment for heavier cars in the EU's largest economy was introduced due to hefty lobbying by the German car industry, and the thresholds were intently chosen to include large parts of the German car manufacturers' fleets in the green categories as opposed to EU competitors. The German environmental NGO Deutsche Umwelthilfe (2013) brought this to light after seeking an information injunction that also involved the European Court of Justice (C-515/11). This former German regime is an early example of institutional greenwashing. While it was abolished and replaced by a solid labelling regime based on absolute and comparatively strict thresholds (Table 1 and Sections 7.2), it remains a remarkable example of the risk of regulatory capture at the national level. Given that regulatory capture can also arise at the EU level, the EU co-legislators would have to take into account this risk in the process of harmonising the car labels.

5.2 Obstacle to financial market access

If designed properly, car labels could play an important role in the European financial market. The European auto asset-backed securities (auto ABS) industry is required by law to publish environmental performance information on vehicles (i.e., car labels) financed by loans or leases.[12] Despite this requirement, there does not yet exist an agreed-upon definition of a green

[12]Regulation (EU) No. 2017/2402 and the loan-level data template Annex 5, data field AUTL57, "Energy Performance Certificate Value" of the European Securities and Markets Authority.

auto ABS. Therefore, mutual fund investors reporting sustainability risks in compliance with the Sustainable Finance Disclosure Regulation[13] face the challenge of identifying and using sustainability-related metrics for their auto ABS investments. One relatively easy solution would be using the car labels from the loan-level data for reporting purposes. However, due to their inconsistencies across countries, car labels are currently being disregarded for credit or climate risk analyses.[14] A single meaningful standard for European car labels would provide an important element for creating a standardised European green auto ABS. Next to mutual funds, further users of vehicle-related sustainability information are banks, insurance companies, rating agencies, the Eurosystem, and scholars (e.g., Panizza et al., 2022; André et al., 2022). They all depend on a standardised definition of the European car label to calculate sustainability metrics, such as the Green Asset Ratio for banks, perform credit and climate risk analyses, or evaluate the effectiveness of these labels across the EU.

6 Learning from EU energy-efficiency labels for household appliances

For other areas of retail products, the EU has established energy labels that offer consumers direct insight into the energy efficiency and consumption of specific products. These labels have proven successful at informing consumers and steering their choices towards more energy-efficient products (Section 2.1).

6.1 New labels for energy-related products under Regulation (EU) 2017/1369 and delegated acts

Regulation (EU) 2017/1369 lays down the current framework for labelling energy-related products according to their energy efficiency, energy consumption, and use of other resources to allow consumers to choose more efficient products in order to reduce their energy consumption.

[13] Articles 6, 8, and 9 of Regulation (EU) 2019/2088.

[14] In their replies to ESMA's public consultation on changes to the securitisation disclosure templates (ESMA12-2121844265-3053) associations representing the banking, securitisation, and insurance industry (10 in total) ask for a removal of the car label since it "can be misleading and unhelpful" (reply of Joint Associations, p. 15).

This labelling regime only applies to new (not second-hand) products and does not apply to means of transport for persons or goods.[15] Manufacturers and importers (suppliers) must ensure that each product placed on the market is accompanied by accurate printed labels and product information sheets free of charge.[16] Dealers have to display the label provided by the supplier in a visible manner, including for online distance selling, and make the product information sheet available to customers.[17]

The energy labels under Regulation (EU) 2017/1369 are graphic diagrams with a closed scale using only letters from A to G, each letter representing a class and each class corresponding to energy savings, in seven different colours from dark green to red, in order to inform customers about energy efficiency and energy consumption.[18] The EC determines the specificities of each label and the product to which it applies in delegated acts.[19] The current energy labelling regime covers the household appliances listed in the Appendix Table A2. Some of the labels have replaced and rescaled previous labels under Directive 2010/30/EU.

6.2 Old labels for energy-related products under Directive 2010/30/EU and delegated acts

Regulation (EU) 2017/1369 repealed a similar, less ambitious previous regime under Directive 2010/30/EU.[20] Some labels continue to exist under the previous regime of Directive 2010/30/EU and have not yet been modified or updated under the new regime (see Table A3).

The elder energy labels under Directive 2010/30/EU look very similar to the new ones under Regulation (EU) 2017/1369. They are all colour-coded in the green-yellow-red scale and are accompanied with a letter grading. Like the new energy labels, most old labels use a scale of seven label categories. However, some labels have been gradually tightened and first rescaled to a scale ranging from A+ to F, then to a scale ranging from A++ to E, and then to a scale ranging from A+++ to D. This applies to air conditioners whose label was rescaled

[15] Article 1(2) Regulation (EU) 2017/1369.
[16] Articles 3(1), 2(14) Regulation (EU) 2017/1369.
[17] Article 5(1) Regulation (EU) 2017/1369.
[18] Article 2(14) Regulation (EU) 2017/1369.
[19] Article 16(1) Regulation (EU) 2017/1369.
[20] Directive 2010/30/EU.

every two years between 2013 and 2019.[21] Other products, including space heaters that use boilers, cogeneration, or heat pumps, as well as low-temperature heat pumps, initially adopted a nine-ladder scale ranging from A++ to G. This scale was later condensed to range from A+++ to D.[22] This development aligns with research indicating that shorter scales are more effective in influencing consumer product choices (Section 2.2.1). Car labels do not face similar issues as most countries have adopted a seven-ladder scale.

6.3 Label review and rescaling in light of technological progress

Both the old and new regimes for energy labels aim to maintain the labels' information value over time by adapting them to energy efficiency improvements in the respective product category due to technological progress. Directive 2010/30/EU mandated the EC to review the classification based on evidence that its information value becomes obsolete because a significant proportion of the respective products is categorised in the two highest energy efficiency classes.[23] Some delegated regulations require the EC to review the technological progress at the latest after five years.[24] The new regime under Regulation (EU) 2017/1369 established a product database held by the EC to conduct market surveillance on evolving energy efficiency data.[25] Regarding periodic review and rescaling, it seeks a standardised approach to existing and new labels. Labels that continue under the previous regime are meant to be harmonised consistently with the new ones on a scale from A to G.[26] Technological progress is supposed to lead to rescaling once the EC estimates that either 30% of the respective products fall in the top energy efficiency category A or 50% of the products fall into the top two energy efficiency categories A and B.[27]

6.4 Lessons for car labels

The EU energy-efficiency labels are an example of a successful energy-related consumer information tool. As such, they can serve as a role model for unified EU car labels. Cars

[21] Article 3(4) and Annex III Commission Delegated Regulation (EU) No 626/2011.
[22] Article 3 and Annex III Commission Delegated Regulation (EU) No 811/2013.
[23] Article 10(4) para. 4 Directive 2010/30/EU.
[24] Article 7 Commission Delegated Regulation (EU) No 626/2011.
[25] Article 12 Regulation (EU) 2017/1369.
[26] Article 11(5) Regulation (EU) 2017/1369.
[27] Article 11(6) Regulation (EU) 2017/1369.

are in fact an outlier compared to household appliances. While energy labels are unified across Europe and offer the exact same information to all EU consumers, car labels diverge starkly between Member States (Section 3). An energy label is a well-known feature that informs various consumer purchase decisions across the EU (Section 2.1). In addition, their regulatory governance provides a solid framework that could inspire EU car labels. The delegation of rule-making power to the EC via delegated acts could prove equally effective in the context of car labels (Section 7, Table A4). Similarly, a periodic label review and rescaling process would make sure that the label does not stagnate against an evolving market and steers towards the more ambitious products.

7 Proposal for a single EU car label

Although there are limits to labelling methods and "in some circumstances the most environmentally sustainable option is no purchase at all" (Horne, 2009, p. 181), we argue in favour of a standardised car label that uniformly applies in all EU Member States. The current state of label fragmentation across the EU (Section 3) undermines the single market of cars, potentially creating cross-border obstacles to trade. Consumers in different countries see different classifications of the very same car. This weakens the EU's effort to decarbonise the transport sector. It also has the potential to harm consumer confidence in the labels and to foster mistrust in climate change-related energy policies. If well designed, a single car label could nudge consumers more effectively to buy cars that consume less fuel or energy and emit less CO_2 . It would help the EU reach its decarbonisation goals and foster the single market of passenger vehicles. While the need for a single car label is clear, its modalities are up for debate and pondering. To reform the car labelling regime, a new regime needs proper legal ramifications, i.e. an appropriate legal basis, a legal act that fits the purpose, and suitable monitoring and supervision. In Table A4, we outline different legal options for introducing a new car label. We suggest following the example of EU energy-efficiency labels and delegating the power to adopt the specific thresholds and requirements of the EU-wide label to the European Commission by means of a delegated regulation.

7.1 Scope of application: New and second-hand cars and vans

Broad coverage across all Member States would increase the effectiveness of the car label. In addition to cars, the label should preferably apply also to all newly registered vans. The respective thresholds for cars and vans would differ in light of their fleet-wide CO_2 emission targets. Given the importance of the second-hand car market in the EU, it makes sense to apply the label to second-hand cars as well. As the average CO_2 emissions from new passenger cars in the EU have declined over the past two decades (EEA, 2024a), second-hand cars emit, on average, more CO_2 than new cars. However, this is only the average, and comparing individual new and second-hand cars can produce different results. Fuel efficiency shows slightly different results. While the average fuel consumption of cars in the EU declined steadily between 1990 and 2012, it rose again from 2013 onwards (EEA, 2019). Our analysis of vehicles registered in 2021 to 2023 supports this finding: There is a rightward shift of the fuel consumption distributions for both petrol and diesel cars over the years 2021 to 2023 (see Appendix, Figure A1, Panels C and D). Hence, even on average, second-hand cars are not necessarily less fuel-efficient than new ones. This argues in favour of applying the same scales to new and used cars and introducing two mandatory colour-coded scales for CO_2 emissions and fuel/energy efficiency to enhance comparability (Section 7.3). Another important element is the type of setting in which the car label must be used in terms of use modalities. To ensure broad coverage and increase its effectiveness, the label should be ideally displayed in all offline and online settings where cars or vans can be purchased, leased or rented. In addition, it could be included in the product descriptions on the manufacturers' websites. These measures would secure the interested buyers' exposure to the label.

7.2 Disclosure of CO_2 emissions and consumption of energy source (basic label)

We propose a car label with two absolute measures: (i) the vehicle's combined CO_2 emissions in g/km and (ii) the combined consumption of the respective energy source in a) l/100 km (fuel for petrol, diesel and LPG vehicles), b) kg/100 km (gas for gas vehicles, hydrogen for fuel cell

vehicles), or c) kWh/100 km (electricity for EVs). In the case of plug-in hybrid vehicles (PHEVs), the label should list the consumption rates in both modalities, i.e. for fuel use in l/100 km and electricity use in kWh/100 km. This would add information for EVs and PHEVs compared to the current regime. In addition to the overall combined fuel or energy consumption, the label could state the vehicle's consumption in four different modalities of use, i.e. within cities, on city outskirts, country roads, and highways, which follow the four WLTP test phases "low", "medium", "high", and "extra high" under Regulation (EU) 2017/1151. This would give consumers a better understanding of the vehicle's specific fuel or energy consumption, depending on their prevalent vehicle use. The label could further state the average range in EVs' all-electric modality and the equivalent all-electric range for PHEVs. The latest German car label, effective since May 2024, and the Canadian EnerGuide label give valuable examples for including comprehensive information.[28]

7.3 Two scales (A to G) for CO_2 emissions and fuel or energy efficiency (coloured label)

The range of different vehicle models on European roads varies considerably in terms of fuel and electricity consumption and CO_2 emissions, with some models being significantly more efficient or less emitting than others (Figure 3). To make both transparent to consumers, we propose a coloured label with two colour-coded scales linked to empirical data and regulatory requirements, one for fuel or energy efficiency and one for CO_2 emissions to compare different vehicles more easily. Ideally, this would build on existing energy-efficiency labels (Section 6.2) and have a seven-scale letter grading.

7.3.1 Reasons for two scales

Given that CO_2 emissions and fuel economy are two pieces of information that matter to consumers, we advocate for both elements to have their own scale. While both matter equally under Directive 1999/94/EC, a single colour code focuses consumer attention only on one of the two elements. Six out of ten EU countries with coloured labels focus on CO_2 emissions, and

[28] See Annex I Pkw-EnVKV 2024 (German label), vehicles.nrcan.gc.ca (Canadian label).

four on fuel consumption (Section 3.1.3). The display of one colour code for CO_2 emissions and another for fuel/energy efficiency would help consumers disentangle the two elements and make an informed decision based on both. The colour code for energy efficiency is also important to better compare EVs and PHEVs. While EVs can be graded A regarding direct CO_2 emissions, their energy efficiency varies considerably across car models. To help consumers compare the energy efficiency of electric vehicles and the fuel efficiency of petrol and diesel cars, the label should include a specific colour-coded scale for energy/fuel efficiency based on absolute values. The ranking could be based either on a comparison within the vehicle group based on engine type (i.e., EVs with EVs)[29] or between vehicle groups (i.e., EVs with ICEVs). A comparison between vehicle groups could strengthen consumers' awareness of a vehicle's overall energy efficiency, where EVs currently seem to outperform ICEVs (IEA, 2024, p. 149). However, comparing different engine types regarding energy efficiency risks creating confusion among consumers about the point of comparison. Hence, regarding fuel or energy efficiency, we propose a comparative ranking within vehicle groups based on empirical data from the EEA on the fuel or energy efficiency of different engine types.

7.3.2 Thresholds of colour-coded scale for fuel or energy economy

As there is no mandatory fuel economy target in the EU, we suggest aligning the colour-coded scale for fuel economy with the latest empirical evidence from newly registered cars in the EU. Figure 4 illustrates this. The fuel economy label has different units depending on the vehicle's fuel type. The reference point for the D rating is the median fuel consumption of unique vehicle models registered in the EU in 2023 (Figure 3 Panels A, B and C). The choice of the median value of the fuel efficiency distribution incentivises manufacturers to improve future car models' fuel/energy efficiency. Starting from D, the absolute thresholds for the remaining six rating categories could be based either on pre-defined bin widths for each rating class or on percentiles of the empirical distributions.[30] For the remainder of this study, we propose a predefined fixed

[29] Weiss et al. (2024) propose various options for categorising EVs according to their energy efficiency in a car label (A to G).

[30] For instance, a bin width of 1 l/100km would imply the following rating thresholds for petrol-fueled vehicles: A = [0-4); B = [4-5); C = [5-6); D = [6-7); E= [7-8); F = [8-9); G= [10 and above). If equidistant percentiles (with a distance of 1/7) were applied the density in Figure 3, Panel A, the thresholds for petrol-fueled vehicles

bin width for each fuel type. The resulting rating thresholds are indicated in italics in Figure 4. To account for the general technological progress and, therefore, increases in efficiency, we suggest updating the thresholds based on empirical data. This could be done using the EEA data for vehicles registered in the previous year. The process could follow the model of energy efficiency labels for household appliances (Section 6.3) by mandating a rescaling once 30% of cars fall into category A or 50% fall into categories A and B.

[Figure 4 about here]

7.3.3 Thresholds of colour-coded scale for CO_2 emissions to follow EU's decarbonisation targets

Like the fuel economy label, the CO_2 emissions label should be time-varying. However, instead of using historical values, we suggest aligning the label's thresholds with the EU's average CO_2 goals for newly registered vehicles in the EU. These targets are 93.6 gCO_2/km for cars and 153.9 gCO_2/km for vans in 2025-2029, 49.5 gCO_2/km for cars and 90.6 gCO_2/km for vans in 2030-2034.[31] From 2035 onwards, only cars and vans emitting 0 gCO_2/km will be registered.[32] Figure 5 illustrates the coloured labelling scale for cars. The mandatory average of CO_2 emissions should constitute the midpoint of category D in the relevant time period. At the same time, the thresholds for the rating classes could be based on a combination of pre-defined bin widths and additional requirements, such as A being assigned exclusively to zero-emission vehicles.[33] For illustration purposes, we propose a bin width of 20 gCO_2/km, which lies in the range of bin widths used by the Member States in Table 1. The resulting rating thresholds the period 2025-2029 are indicated in italics in Figure 5. It is advisable to apply this label to second-hand vehicles to raise prospective buyers' awareness of the extent to which the vehicle is aligned with the EU's emissions targets.

would be the following: A = [0-5.4); B = [5.4-5.8); C = [5.8-6.3); D = [6.3-6.8); E= [6.8-7.3); F = [7.3-8.6); G= [8.6 and above).

[31] Annex II Part A and B Commission Implementing Decision (EU) 2023/1623.

[32] Article 1 (5a)(a) Regulation (EU) 2019/631 as introduced by Article 1(1)(b) Regulation (EU) 2023/851.

[33] For instance, the CO_2 thresholds for cars in the period 2025-2029 could be based on bin width of 10 gCO_2/km for category D and lower, with A being reserved for zero-emission vehicles, and the remaining CO_2 range being distributed equally between B and C. This procedure would yield the following CO_2 thresholds: A = [0]; B = (0-44.3]; C = (44.3 - 88.6]; D = (88.6-98.6]; E = (98.6-108.6]; F = (108.6-118.6]; G = (118.6 and above].

[Figure 5 about here]

7.3.4 Application of the proposed fuel and CO_2 car labels on the EU car fleet

We apply the proposed thresholds for fuel economy and CO_2 emissions, (Figures 4 and 5) to about 28.85 million passenger vehicles registered in the EU between 2021 and 2023. The resulting rating distributions are presented in Figure 6. We observe that if the label were based on the 2025-2029 EU emissions targets, the majority of vehicles would receive a D rating or lower for CO_2 emissions. Notably, the proposed labelling scheme shifts the distribution of the car fleet similarly to the right, as under the application of the current Austrian or German methodologies (see Figure 2, Panels A and F). In contrast, our proposed fuel economy ratings generate a right-skewed distribution, with most vehicles falling within the B to D range.

[Figure 6 about here]

Additional analyses in the Appendix reveal that among the 12.3% of vehicles with an A rating for CO_2 emissions, approximately 35% are rated D or lower for fuel economy (see Table A5). This finding confirms the need to improve the transparency regarding both CO_2 emissions and fuel economy. We further analyse the rating distributions across individual countries and observe a distinct divergence between Eastern and Western Europe for the CO_2 label (see Figures A2 and A3). In Western European countries (e.g., AT, BE, DK, FI, FR; IE, LU, MT, NL, SE), a sizeable portion of vehicles fall into the A and B rating categories. In contrast, Eastern European countries (e.g., CZ, EE, ES, HR, HU, PL, SI, SK) predominantly rely on ICEVs, which are rated between E and G. This highlights that there is a considerable potential for reducing emissions in these countries by providing consumers with information about vehicle emission levels that is easy to understand.

8 Conclusion

This study finds a substantial fragmentation of (coloured) car labels in the EU, as the national implementations of Directive 1999/94/EC strongly diverge regarding their focus on either

CO_2 emissions or fuel economy, relative or absolute methodology, and different thresholds among countries using the same methodology. We review economic and behavioural research on product labelling, draw insights from the adoption of energy efficiency labels for electric household appliances, and examine the legal implications of establishing a standardised car label across the EU.

We propose to reform the current car labelling framework by introducing a standardised, EU-wide label with two coloured rating scales: one for CO_2 emissions and one for fuel efficiency. Each scale shall make of use absolute rating thresholds. The adoption of this dual-scale approach is sensible due to the following reasons. First, highlighting both aspects visually in coloured scales allows consumers to compare vehicles on two different aspects. These aspects align with the EU's two policy goals of decarbonisation and energy-saving. Second, the single-scale approach under the current national labelling regimes with CO_2 -based coloured labels rates all electric vehicles in category A although their energy consumption per km differs starkly across models. An additional coloured label for fuel efficiency would therefore offer a more transparent assessment of a vehicles' environmental and economic impact. Third, once the EU achieves its decarbonisation targets, the focus will shift towards improving fuel efficiency, rendering the CO_2 -based label obsolete.

Studies have shown that consumers would also benefit from the new car label reporting hidden costs such as the national vehicle tax, the average price of the relevant energy source (fuel, electricity) from the last year, and the expected future CO_2 prices. Vehicle noise emissions and air pollution, e.g., via particulate matter, could potentially also be considered. However, these aspects are beyond the scope of this study and are left for future research.

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Thøgersen, J. (2000). Psychological determinants of paying attention to eco-labels in purchase decisions: Model development and multinational validation. *Journal of Consumer Policy*, *23*(3), 285-313. doi: 10.1023/A:1007122319675

Tranter, R., Bennett, R., Costa, L., Cowan, C., Holt, G., Jones, P., ... Vestergaard, J. (2009). Consumers' willingness-to-pay for organic conversion-grade food: Evidence from five eu countries. *Food Policy*, *34*(3), 287-294. doi: 10.1016/j.foodpol.2009.03.001

Waechter, S., Sütterlin, B., Borghoff, J., & Siegrist, M. (2016). Letters, signs, and colors: How the display of energy-efficiency information influences consumer assessments of products. *Energy Research & Social Science*, *15*, 86-95. doi: 10.1016/j.erss.2016.03.022

Weiss, M., Winbush, T., Newman, A., & Helmers, E. (2024). Energy consumption of electric vehicles in europe. *Sustainability*, *16*(17), 7529.

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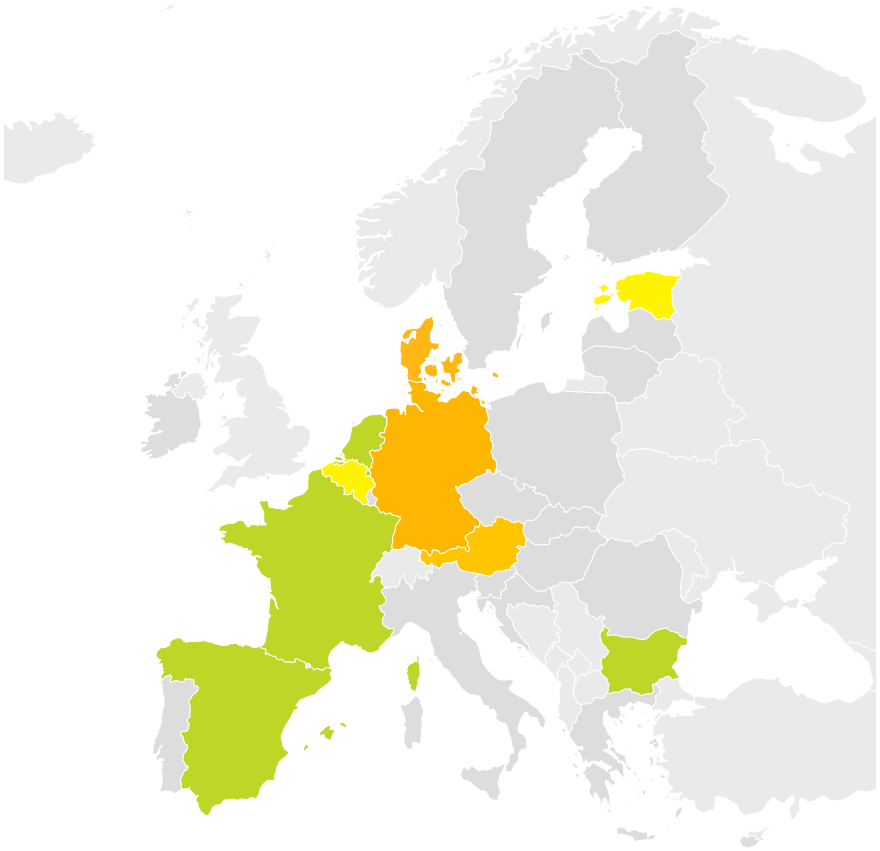
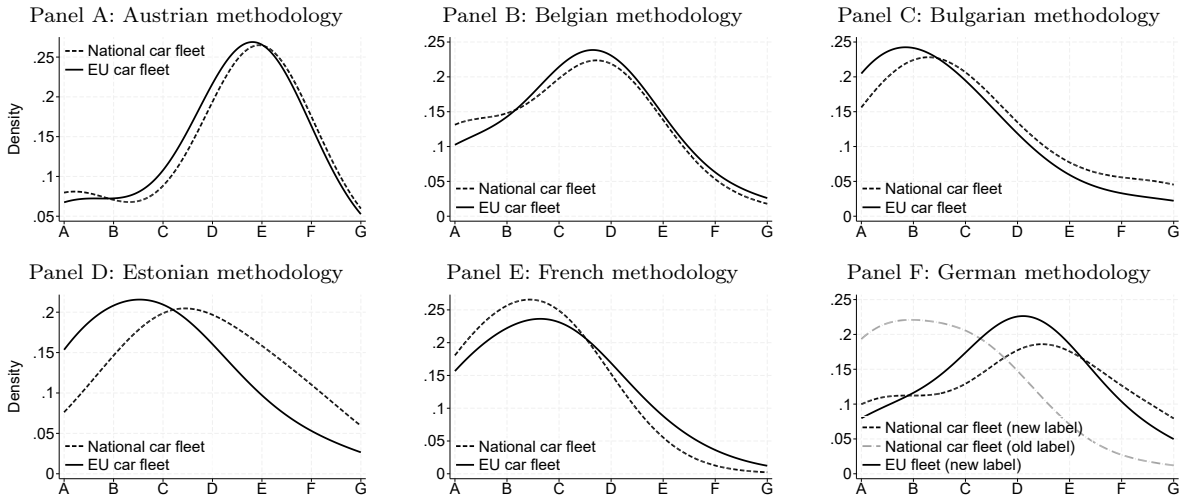
Figures

Figure 1: EU-wide car labels of a small SUV



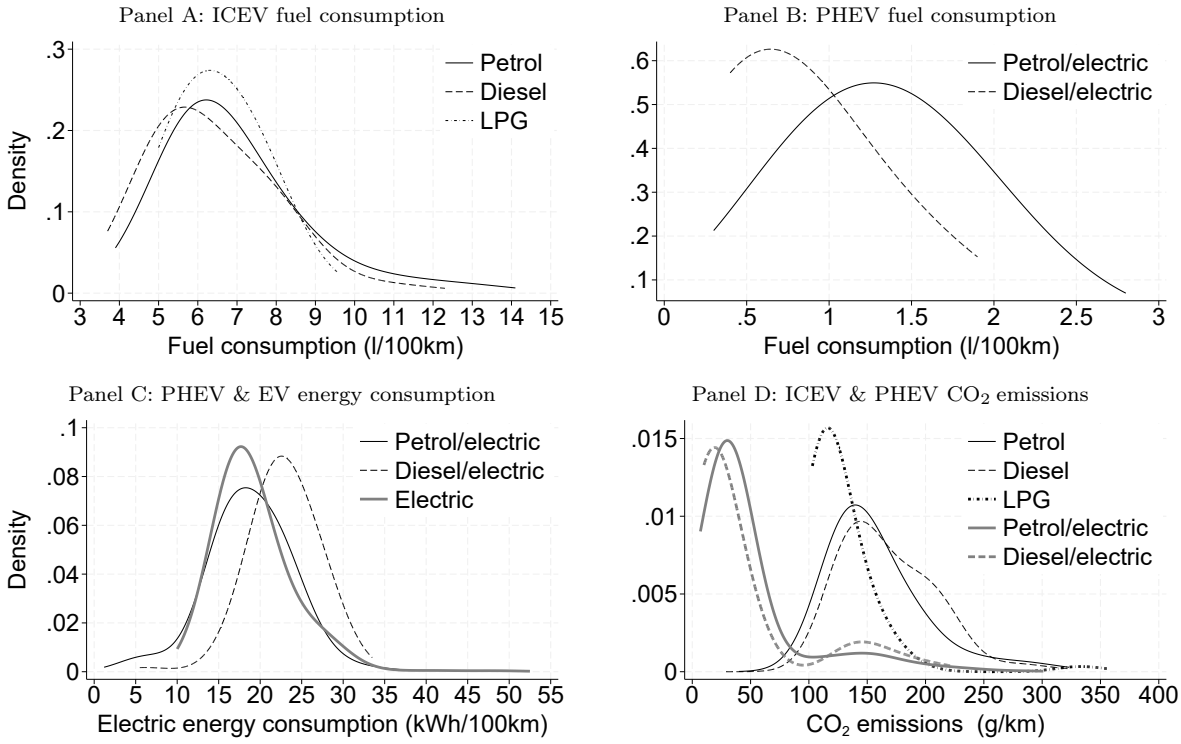
The figure illustrates the divergence in car labels across EU countries. The labels refer to Volkswagen T-Roc 1.5 TSI (2022-2024), with a fuel consumption of 6.1 l/100km and CO_2 emissions of 138 g/km. The SUV's label varies from B (Denmark) to E (Germany). Source: Own calculations based on Table 1, coches.idae.es (Spain), www.anwb.nl (Netherlands).

Figure 2: CO_2 car label distributions using national labelling methodologies



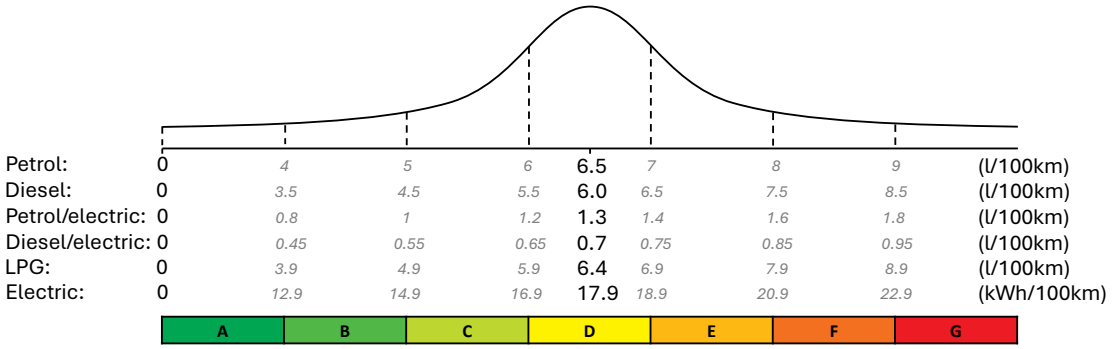
The figure depicts the Gaussian kernel density estimates of car labels, defined using the national CO_2 labelling methodologies (see Table 1). The labels are applied to passenger vehicles registered in the respective country (dashed line) and across the whole EU (solid line) between 2021 and 2023 (28.85 million vehicles in total). The data come from the EEA (2024b) database.

Figure 3: Fuel efficiency and CO_2 emissions of passenger vehicle models registered in the EU in 2023



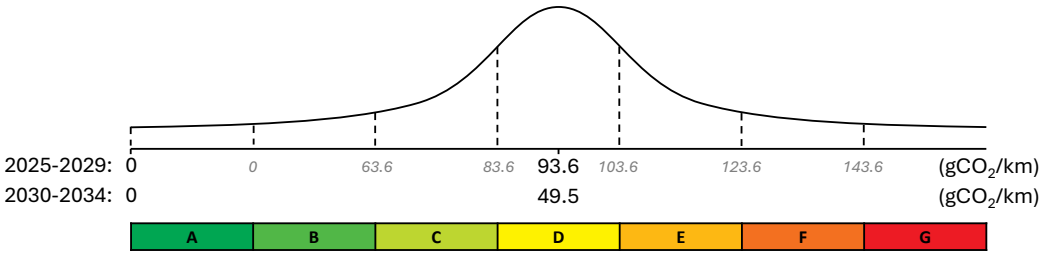
This figure depicts the Gaussian kernel density estimates of unique vehicle models' fuel efficiency and CO_2 emissions. A vehicle model is defined as unique combination of the vehicles' i) type approval number, ii) type, iii) variant, and iv) version. The density estimates were smoothed by applying bandwidths 1, 0.5, 3, 20 for Panels A, B, C, and D, respectively. Panel A reports the petrol consumption in l/100km for ICEVs, shown as a solid line; diesel consumption, depicted with a dashed line; and liquefied petroleum gas consumption, represented by a dot-dashed line. Panel B mirrors Panel A but focuses on PHEVs and battery use. Panel C reports the energy consumption in kWh per 100km for petrol- and diesel-powered PHEVs (solid and dashed lines) and pure electric vehicles (thick solid grey line). Panel D reports the CO_2 emissions for all the above engine types, except for EVs, as they have direct emissions of 0 gCO_2/km. Only vehicle registrations in the EU in 2023 are considered. The data come from EEA (2024b).

Figure 4: Fuel and electricity economy



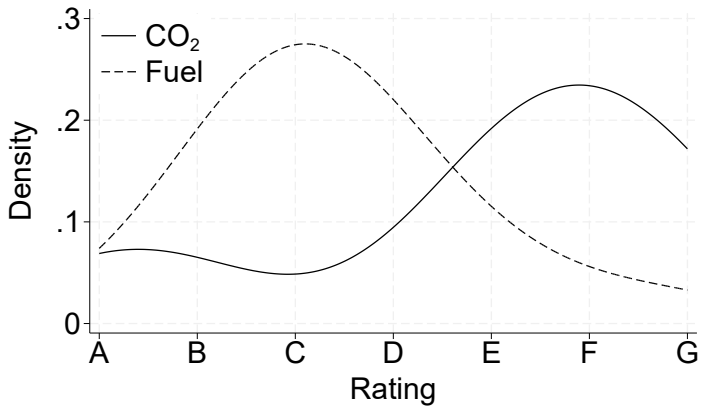
This figure reports the median value of fuel and electricity efficiency for all vehicle models registered in the EU in 2023, suggested to fall under rating D. The authors' proposed rating thresholds are presented in italicized gray font. Source: own calculations, EEA (2024b).

Figure 5: CO_2 emissions according to decarbonisation targets



This figure reports the EU's mandatory car fleet CO_2 emission targets, suggested to fall under rating D. The authors' proposed rating thresholds are presented in italicized gray font for the period 2025-2029. Source: Annex II Part A and B Commission Implementing Decision (EU) 2023/1623.

Figure 6: EU car fleet distribution under the proposed labels



This figure depicts the rating distributions for the EU car fleet under the two proposed labelling systems: the CO_2 -based car label (represented by a solid line) and the fuel-efficiency car label (dashed line). It includes 28.85 million passenger vehicles registered in the EU between 2021 and 2023. The rating thresholds for the CO_2 emissions (2025-2029) and the fuel economy come from Figures 5 and 4, respectively. Source: own calculations, EEA (2024b).

Tables

Table 1: National car labels

MS	Value	Unit	Coloured car label classification						
			A	**B**	**C**	**D**	**E**	**F**	**G**
AT†	Abs.	gCO_2/km	0-20	21-40	41-65	66-120	121-160	161-220	>220
BE	Abs.	gCO_2/km	1-74	75-99	100-124	125-149	150-174	175-199	≥200
BG	Rel.	gCO_2/km in %	<-25%	-15 - -25%	-5 - -15%	-5% - +5%	+5 - +15%	+15 - +25%	≥+25%
		153*	<115	115-130	130-146	146-161	161-177	177-192	≥192
CY			Basic label						
CZ			Basic label						
DE	Abs.	gCO_2/km	0	1-95	96-115	116-135	136-155	156-175	≥176
DK‡	Abs.	km/l	>18.1	15.4-18.1	14.3-15.3	12.5-14.2	11.8-12.4	10.5-11.7	<10.5
EE	Abs.	gCO_2/km	≤100	101-120	121-135	136-150	151-170	171-200	≥201
ES	Rel.	l/100km in %	< -25%	-15 - -25%	-5 - -15%	mean	+5 - +15%	+15% - +25%	> +25%
FI			Basic label						
FR	Abs.	gCO_2/km	0-100	101-120	121-140	141-160	161-200	201-250	>250
GR			Basic label						
HR			Basic label						
HU			Basic label						
IE			Basic label						
IT			Basic label						
LT			Basic label						
LU			Basic label						
LV			Basic label						
MT			Basic label						
NL	Rel.	l/100 km in %	<-15%	-15 - -5%	-5 - +5%	+5 - +15%	+15% +25%	+25 - +35%	≥+35%
PL			Basic label						
PT	Rel.	l/100km or km/l in %	Colour-coded, but no thresholds provided						
RO			Basic label						
SE			Basic label						
SI			Basic label						
SK			Basic label						

Column 1, "MS", presents the two-letter ISO country code for each EU Member State and provides hyperlinks to the websites containing the respective national laws. Column 2, "Value", indicates whether the label is based on absolute (Abs.) or relative (Rel.) values, and column 3, "Units", reports the units that the classification is based on. Column 4, "Coloured car label classification", reports the thresholds used to colour-code the car labels from best (class A, green) to worst (class G, red). †Austria has implemented a continuous label ranging from 0 (dark green) to >220 (dark red) without a letter grading: the dashed vertical lines indicate the approximate thresholds corresponding to the continuous colour scale. ‡ Denmark has its own ten-fold scale ranging from A+++ to G, with a shifted colour scale (A++: dark green, A: yellow, B: light orange, C: dark orange, D to G: red). For simplicity purposes, the table does not display the scales A+++, A++, A+. *The asterisk indicates the reference value of the CO_2 emissions (g/km) used for calculating the percentage of the relative car label. Source: National legislations (Appendix Table A1).

Internet Appendix for "Reforming EU Car Labels: How To Achieve Consumer-Friendly Transparency?"

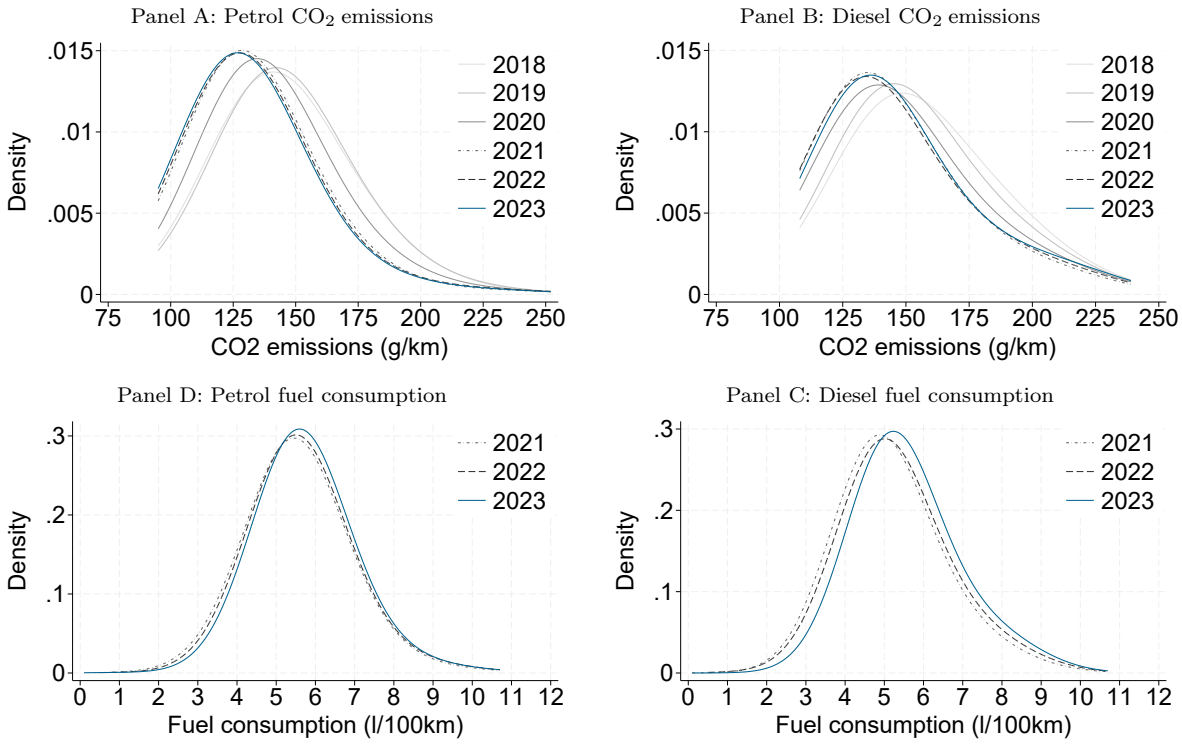
This Internet Appendix contains supplementary materials for the article titled "Reforming EU Car Labels: How To Achieve Consumer-Friendly Transparency?".

A Data

The empirical analyses are based on new passenger car registrations obtained from the European Environment Agency (EEA, 2024a). We restrict the sample to registrations years 2018 to 2023 due to poor data coverage for earlier years. Since the main purpose of the EEA database is the monitoring of vehicles' CO_2 emissions, the coverage of NEDC- and WLTP-based CO_2 value is very high. In contrast, the information on fuel consumption becomes available only from the year 2021 onwards.

We remove outliers for CO_2 emissions at the 99th percentile. Outliers for the fuel consumption are removed at the 1st and the 99th percentiles. Furthermore, we populate the missing CO_2 and fuel consumption information using the average value of the same vehicle models registered in the same year. Following Hackmann et al. (2024), the vehicle model is defined as a unique combination of i) the type approval number, ii) type, iii) version, and iv) variant of a car.

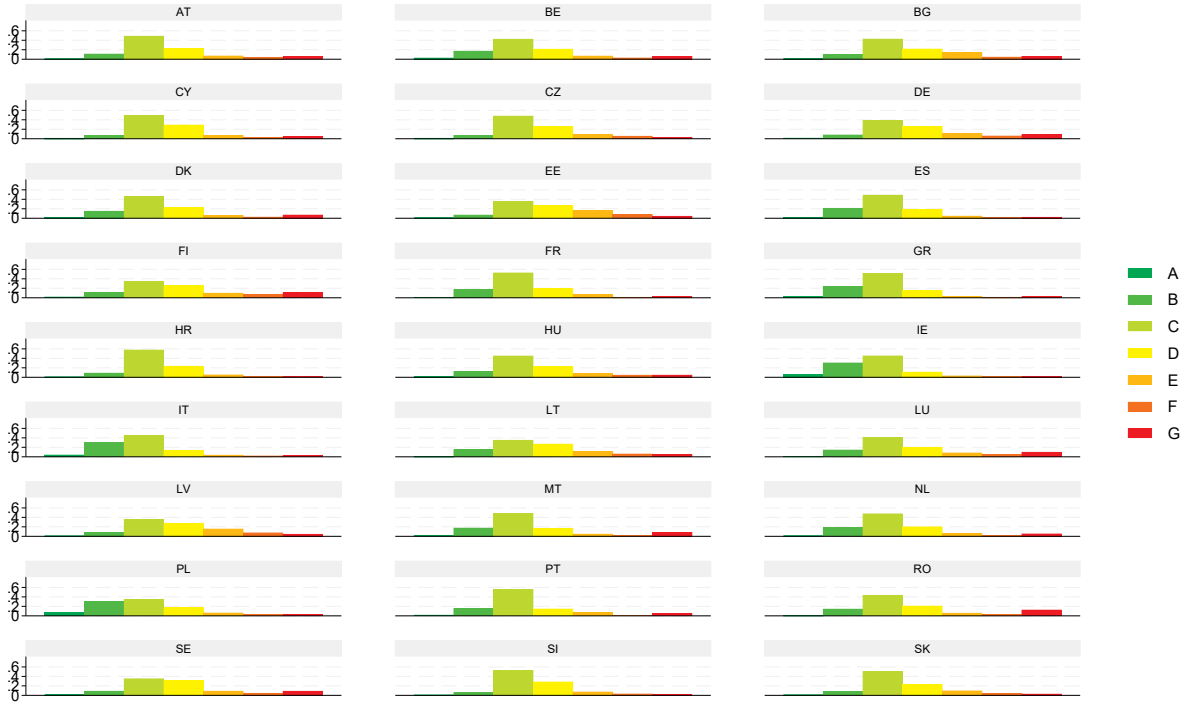
Figure A1: Fuel efficiency and CO_2 emissions of passenger vehicles over time



This figure depicts the Gaussian kernel density estimates of petrol- and diesel-powered vehicles' fuel consumption and CO_2 emissions for different registration years. The plots are based on new vehicle registrations in the EU in the years 2018 to 2023 for CO_2 emissions and 2021 to 2023 for fuel consumption. The data come from EEA (2024b).

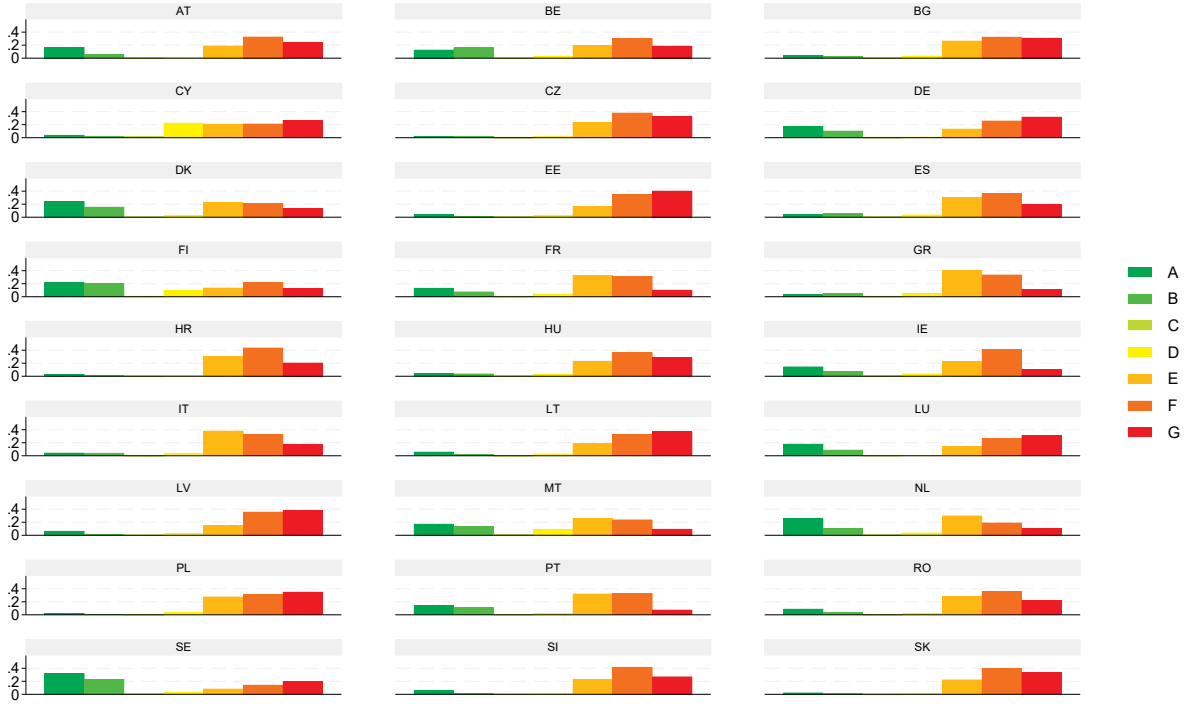
B Figures

Figure A2: Car label distribution under the proposed fuel economy label



The figure depicts the rating distribution of the national car fleets in EU Member States under the proposed fuel economy label. The underlying vehicles represent new passenger vehicles registered between 2021 and 2023. The rating thresholds come from Figure 4. Source: own calculations, EEA (2024b).

Figure A3: Car label distribution under the proposed CO_2 label for 2025-2029



The figure depicts the rating distribution of the national car fleets in EU Member States under the proposed CO_2 label for 2025-2029. The underlying vehicles represent new passenger vehicles registered between 2021 and 2023. The rating thresholds come from Figure 5. Source: own calculations, EEA (2024b).

C Tables

Table A1: National car label legislations

Country	National regulation	Source
AT	Änderung der Personenkraftwagen-Verbraucherinformationsverordnung 2018 – Pkw-VIV 2018	Link
BE	Arrêté royal modifiant l'arrêté royal du 5 septembre 2001 concernant la disponibilité d'informations sur la consommation de carburant et les émissions de COainfera2bendinferb à l'intention des consommateurs lors de la commercialisation des voitures particulières neuves	Link
BG	Наредба за изискванията за етикетиране на нови пътнически автомобили и за предоставяне на информация относно разхода на гориво и на емисиите на въглероден диоксид	Link
CY	ΚΔΠ 622/2003, Το Περί Εμπορικών Περιγραφών (Ενεργειακός Οδηγός - Επιβατηγά Αυτοκίνητα) Διάταγμα 2003, ΕΕ Παρ.III(1), Αρ. 3739, Σελ. 3643, 25/7/2003	Link
CZ	Vyhláška o náležitostech informačních štítků a plakátů s údaji o spotřebě pohonných hmot a emisích CO2 při prodeji nových osobních vozidel	Link
DE	Zweite Verordnung zur Änderung der Pkw-Energieverbrauchskennzeichnungsverordnung	Link
DK	BEK nr 655 af 20/06/2012 - Bekendtgørelse om energimærkning m.v. af nye person- og varebiler	Link
EE	Uue mootorsõiduki kasutajale antavate andmete loetelu ja kasutaja teavitamise kord	Link
ES	Real Decreto 837/2002, de 2 de agosto, por el que se regula la información relativa al consumo de combustible y a las emisiones de CO2 de los turismos nuevos que se pongan a la venta o se ofrezcan en arrendamiento financiero en territorio español	Link
FI	Valtioneuvoston asetus autojen polttoaineenkulutuksen ja hiilidioksidipäästöjen ilmoittamisesta	Link
FR	Arrêté du 10 avril 2003 relatif à l'information sur la consommation de carburant et les émissions de dioxyde de carbone des voitures particulières neuves	Link
GR	ΚΥΑ 90364_2002 (ΦΕΚ 110_B_31.01.2002) - Πρόγραμμα ενημέρωσης και παροχής πληροφοριών προς τους καταναλωτές σχετικά με την οικονομία καυσίμου και τις εκπομπές CO2 των προς εμπορία νέων επιβατηγών αυτοκινήτων	Link Link
HR	Pravilnik o dostupnosti podataka potrošačima o službenoj potrošnji goriva i službenim specifičnim emisijama CO2 novih osobnih vozila	Link

Continued on next page

Table A1 – continued from previous page

Country	National regulation	Source
HU	12/2002. (III. 14.) GM-KöViM-KöM együttes rendelet az új személygépkocsik üzemanyag-gazdaságossági és szén-dioxid-kibocsátási adatainak közzétételéről	Link
IE	S.I. No. 339/2001 - European Communities (Consumer Information on Fuel Economy and Co2 Emissions of New Passenger Cars) Regulations, 2001	Link
IT	Decreto del presidente della Repubblica 17 febbraio 2003, n. 84, in materia di Attuazione della direttiva europea in tema di dati consumi carburanti ed emissione CO2	Link
LT	Dėl Lietuvos Respublikos aplinkos ministro 2003 m. spalio 8 d. įsakymo Nr. 493 „Dėl Informacijos apie degalų taupymą ir išmetamųjų CO2 dujų kiekį pateikimo vartotojams parduodant naujus keleivinius automobilius tvarkos patvirtinimo“ pakeitimo	Link
LU	Règlement grand-ducal du 6 avril 2001 concernant la disponibilité d'informations sur la consommation de carburant et les émissions de CO2 à l'intention des consommateurs lors de la commercialisation des voitures particulières neuves.	Link
LV	Ministru kabineta 2004. gada 20. jūlija noteikumi Nr. 608 "Noteikumi par marķējumā un reklāmas publikācijās patērētājiem sniedzamo informāciju par jaunu vieglo automobiļu degvielas patēriņu un CO2 izplūdi".	Link
MT	Availability of Consumer Information on Fuel Economy and Carbondioxide Emissions in respect of the Marketing of New Passenger Cars Regulations	Link
NL	Besluit etikettering energiegebruik personenauto's	Link
PL	ROZPORZĄDZENIE MINISTRA GOSPODARKI I PRACY z dnia 28 grudnia 2004 r. w sprawie produktów objętych obowiązkiem zaopatrzenia w informacje istotne z punktu widzenia ochrony środowiska	Link
PT	Decreto-Lei n.º 304/2001, de 26 de novembro	Link
RO	HOTĂRÂRE nr. 343 din 18 martie 2004 privind furnizarea informaţiilor referitoare la consumul de carburant şi emisiile de CO(2) ale autoturismelor noi, destinate cumparatorilor la comercializare	Link
SE	Proposition 2023/24:55 Information om bränsleförbrukning och koldioxidutsläpp vid marknadsföring av nya personbilar	Link
	KOVFS 2018:3 Konsumentverkets allmänna råd om information om nya personbilars bränsleförbrukning och koldioxidutsläpp	Link

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Table A1 – continued from previous page

Country	National regulation	Source
SI	Uredba o informacijah o varčnosti porabe goriva, emisijah ogljikovega dioksida in emisijah onesnaževal zunanjega zraka, ki so na voljo potrošnikom o novih osebnih avtomobilih	Link
SK	Nariadenie vlády č. 384/2004 Z. z. Nariadenie vlády Slovenskej republiky o dostupnosti spotrebiteľských informácií o spotrebe paliva a o emisiách CO2 pri predaji a leasingu nových osobných automobilov	Link

The table provides an overview of national legislations that have implemented the Directive 1999/94/EC.

Table A2: EU energy labels under Regulation (EU) 2017/1369

Appliance	**Current Delegated Act**	**Former Delegated Act**
Electronic displays	Commission Delegated Regulation (EU) 2019/2013	Commission Delegated Regulation (EU) No 1062/2010
Household washing machines and household washer-dryers	Commission Delegated Regulation (EU) 2019/2014	Commission Delegated Regulation (EU) No 1061/2010 and Commission Directive 96/60/EC
Light sources	Commission Delegated Regulation (EU) 2019/2015	Commission Delegated Regulation (EU) No 874/2012
Refrigerating appliances	Commission Delegated Regulation (EU) 2019/2016	Commission Delegated Regulation (EU) No 1060/2010
Household dishwashers	Commission Delegated Regulation (EU) 2019/2017	Commission Delegated Regulation (EU) No 1059/2010
Refrigerating appliances with a direct sales function	Commission Delegated Regulation (EU) 2019/2018	
Household tumble dryers	Commission Delegated Regulation (EU) 2023/2534	
Smartphones and slate tablets	Commission Delegated Regulation (EU) 2023/1669	

This table lists the household appliances for which the EU has introduced energy labels via delegated acts under Regulation (EU) 2017/1369. The last column lists the former delegated acts that have been repealed.

Table A3: EU energy labels under Directive 2010/30/EU

Appliance	**Current Delegated Act**
Air conditioners	Commission Delegated Regulation (EU) No 626/2011
Space heaters, combination heaters, packages of space heaters, temperature control and solar devices and packages of combination heaters, temperature control and solar devices	Commission Delegated Regulation (EU) No 811/2013
Water heaters, hot water storage tanks and packages of water heaters and solar devices	Commission Delegated Regulation (EU) No 812/2013
Domestic ovens and range hoods	Commission Delegated Regulation (EU) No 65/2014
Residential ventilation units	Commission Delegated Regulation (EU) No 1254/2014
Professional refrigerated storage cabinets	Commission Delegated Regulation (EU) 2015/1094
Local space heaters	Commission Delegated Regulation (EU) 2015/1186
Solid fuel boilers and packages of a solid fuel boiler, supplementary heaters, temperature controls and solar devices	Commission Delegated Regulation (EU) 2015/1187
~~Vacuum cleaners~~[a]	~~Commission Delegated Regulation (EU) No 665/2013~~

This table lists the household appliances for which the EU has introduced energy labels via delegated acts that continue to apply under Directive 2010/30/EU despite the new labelling regime under Regulation (EU) 2017/1369.

[a]The EC adopted Commission Delegated Regulation (EU) 2015/1187 establishing an energy label for vacuum cleaners, but it was successfully challenged before European courts. The General Court first dismissed the case (Case T-544/13, *Dyson Ltd v European Commission* (ECLI:EU:T:2015:836)). The appeal before the Court of Justice was partially successful (Case C-44/16 P, *Dyson Ltd v European Commission* (ECLI:EU:C:2017:357)). After the appeal, the General Court annulled the delegated act because it calculated the vacuum cleaner's energy performance based on an empty receptacle, a method that the General Court found neither accurate nor scientifically valid (Case T-544/13 RENV, *Dyson Ltd v European Commission* (ECLI:EU:T:2018:761) paras 62-82.).

Table A4: Legal ramifications

Choice of	Options	Reasons
Legal basis[34]	EU environmental policy competence[35]	Car labels relate to the EU's decarbonisation goal as an environmental policy aim. Directive 1999/94/EC is based on this competence.
	EU energy policy competence[36]	Informing consumers about fuel or energy consumption relates to energy efficiency. The energy efficiency labels under Directive 2010/30/EU and Regulation (EU) 2017/1369 are based on this competence
	EU internal market competence[37]	Harmonising car labels affects the EU's internal market for cars. Many legal acts regulating products in the EU are based on this general competence.
	Recommendation: The EU legislators should base the new car labelling regime on both the EU environmental and energy policy competences. The European Court of Justice accepts using a dual legal basis if the legal acts affects both substance matters equally and the procedures do not substantially differ.[38] A single car label aims to inform consumers about fuel consumption as an energy efficiency aspect and CO2 emissions as an environmental concern related to climate change. Both aspects are equally important and the procedures of Article 192(1) TFEU and Article 194(2) TFEU are similar.	
Legal act[39]	Directive[40]	A directive offers more flexibility to national legislators and is less intrusive regarding EU law subsidiarity. However, this is mirrored by the disadvantage of leaving fragmented rules across the EU single market.
	Regulation[41]	A regulation harmonises market rules more strongly and reduces trade barriers between Member States resulting from diverging legal rules. It does not require national implementation and is better placed to create a level playing field at the EU level. The disadvantage is that a regulation pursues a "one size fits all" approach and does not allow the Member States to choose the means to achieve the required result.

Continued on next page

[34] Legislating on a single EU car label requires a suitable EU competence providing for a legal basis under the principle of conferral, Article 5(2) TEU.
[35] Article 192(1) TFEU.
[36] Article 194(2) TFEU.
[37] Article 114(1) TFEU.
[38] Case C-178/03, Commission of the European Communities v European Parliament and Council of the European Union (ECLI:EU:C:2006:4) paras. 57-60.
[39] When legislating, the EU legislators must choose an appropriate legal instrument, Article 288 TFEU.
[40] Article 288(3) TFEU.
[41] Article 288(2) TFEU.

Table A4 – continued from previous page

Country	National regulation	Source
	Directive[42] or regulation[43] + delegated act by the European Commission[44]	The delegation of power to the EC has the advantage of flexibility and timely reactions to market changes. The process of delegated rule-setting is much swifter than a full legislative procedure involving the European Parliament and the Council. This argues in favour of adopting a framework regulation that establishes the objectives of providing consumers with accurate, robust and comparable information on the fuel and energy consumption and CO_2 emissions of new passenger cars placed on the market. The energy efficiency labels for household appliances under Regulation (EU) 2017/1369 and its delegated regulations provide a useful example.
	Recommendation: Given the current state of label fragmentation, the co-legislators should legislate the general principles of the label in a regulation and empower the EC to specify more technical details by means of delegated regulations. This would enable the EC to modify the label's methodology, values, and adaptations to technological changes more quickly and swiftly than an ordinary legislative procedure.	
Monitoring and supervision	National	The national type approval authorities could approve the data displayed on the car labels alongside the manifold technical requirements within the type approval procedure.[45] The type approval of cars under Regulation (EU) 2018/858 limits immediately health-damaging emissions such as CO, NOx, and particulate matter and includes rules on the measurement of CO_2 emissions of individual cars.[46]
	Supranational	Car labels could be included in the European Environment Agency's (EEA) database of car types and CO_2 emissions to better monitor the achievement of vehicle-related climate targets and measure the effectiveness of these labels.[47] The EC could verify compliance with the label requirements alongside the compliance verification procedure it exercises regarding the type approval requirements.[48]

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[42] Article 288(3) TFEU.
[43] Article 288(2) TFEU.
[44] Article 290 TFEU.
[45] Article 7 Regulation (EU) 2018/858.
[46] Appendix 2 Point 4 Part I 2A Regulation (EU) 2018/858.
[47] See EEA's Datahub "Monitoring of CO2 emissions from passenger cars Regulation (EU) 2019/631".
[48] Article 9 Regulation (EU) 2018/858.

Table A4 – continued from previous page

Country	National regulation	Source
	Mix of national and supranational	To ensure effective supervision and create synergies with the type approval procedure, supervising the car label could be delegated to the national type approval authorities and the EC. While the national type approval authorities would approve the data displayed on the car labels, the EC could verify compliance with the label requirements. In addition, the EEA could monitor the car label data to support timely regulatory updates.
	Recommendation: The institutional governance of the labelling regime would benefit from a mix of supranational and national monitoring and supervision. An amendment to Regulation (EU) 2018/858 would be sufficient to implement these additional institutional competences at the national and EU levels.	

Table A5: Distribution of standardised car labels across the EU

Fuel economy	CO_2 emissions: A	B	C	D	E	F	G	Total
A	0.2	0.4	0.0	0.8	0.7	0.1	0.0	2.1
B	2.5	0.3	0.0	1.9	8.9	2.9	0.2	16.8
C	5.3	1.3	0.0	0.0	14.5	21.2	2.1	44.5
D	2.9	1.4	0.0	0.0	0.5	5.6	10.6	21.0
E	0.7	1.4	0.0	0.0	0.6	0.1	4.5	7.3
F	0.3	0.6	0.0	0.0	0.0	0.0	2.2	3.2
G	0.4	2.6	0.2	0.0	0.1	0.1	1.7	5.1
Total	12.3	8.1	0.2	2.8	25.3	29.9	21.5	100

The table reports the relative distribution of the two proposed car labels for CO_2 and fuel economy for 28.85 million new passenger vehicles registered in the EU between 2021 and 2023. The rating thresholds for the CO_2 emissions (2025-2029) and the fuel economy come from Figures 5 and 4, respectively. Source: own calculations, EEA (2024b).

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