German Environment Agency

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AutoRess Short paper: Criteria for resource-efficient, circular economy-conforming vehicle

Results from the project 'Resource efficient and circular electric cars' (AutoRess) - FKZ 3722 57 101 0

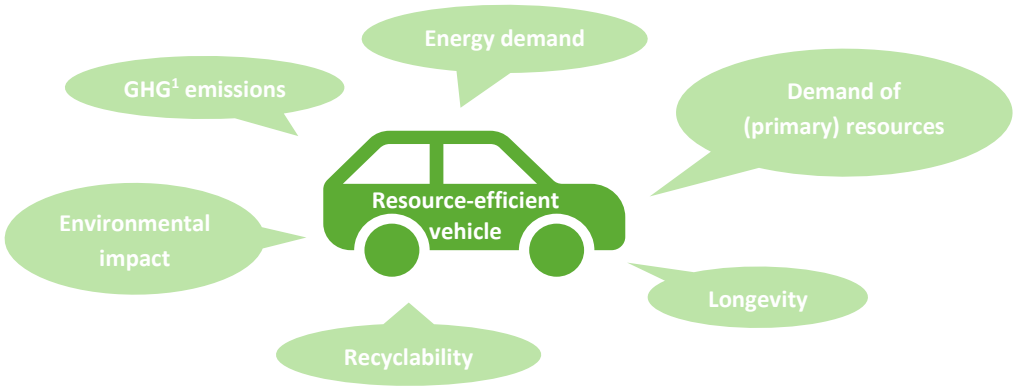
1 Resource efficient and circular economy-conforming vehicles

With the ever-increasing number of cars in recent decades and the trend towards larger, heavier vehicles, greenhouse gas emissions and resource utilisation from vehicle production and use are also rising immensely. In the course of the transition towards electromobility, additional raw materials, some of which are classified as critical, are also required. As this is essential for compliance with the Paris Agreement, the project results only deal with battery electric vehicles.

Vehicle concepts that are as resource-efficient and circular economy-compatible as possible are therefore essential in order to reduce the environmental impact and material requirements during all phases of the vehicle life cycle. As part of the 'AutoRess' project, the following proposals were developed for the definition and criteria for resource-efficient, circular economy-conforming vehicles.

1.1 Proposed definition of a resource-efficient, circular economy-conforming vehicle

Figure 1: Aspects of the proposed definition for a resource-efficient, circular economy conforming vehicle



[1]: Greenhouse gas (GHG) emissions

Source: Own illustration

A battery electric vehicle is defined as resource-efficient and circular-economy-compatible if

- it requires as few **primary raw materials** as possible over its entire life cycle;
- it consumes as little **energy** and emits as few **greenhouse gases** as possible over its entire life cycle;
- it is as **durable** as possible;
- its components can be **recycled** as completely as possible at the end of its life without downcycling.
- its additional **environmental and social impacts** are minimised.

1.2 Major levers on resource efficiency and greenhouse gas emissions

The modelling concerning resource consumption and (greenhouse gas) GHG emissions performed in „AutoRess“ in 10 topic areas of the passenger car sector revealed 3 aspects, that strongly influence the aims set in the project.

According to modelling results, the three major levers on resource efficiency and GHG emissions are

Reduction of vehicle and battery sizes 

Extension of service life 

Higher quantities of recycled content 

2 Criteria

Based on the major levers that werde identified, criteria that have a positive influence on the various aspects of the definition of a resource-efficient vehicle were defined. In addition to the directional certainty of the individual criteria, their verifiability was also at the centre of the selection process.

Table 1: Proposed criteria and their influence on the different aspects of the definition of a resource-efficient, circular economy compatible vehicle

Demand of (primary) resources	GHG emissions	Longevity	Recyclability	Energy consumption	Environ-mental impact
Raw materials index[1]	Product Carbon Footprint[1]	Modular design	Modular design	Product Carbon Footprint	Due diligence obligations
Vehicle dimensions	Recycled content targets	Lifetime guarantee for batteries	Raw materials index[1]	Energy demand in use	Raw materials index[1]
Battery capacity	Vehicle dimensions	Provision of spare parts and software updates	Recycled content targets	Vehicle size	Vehicle dimension
Recycled content					



Vehicle dimensions

The most obvious criterion for the overall raw material consumption of a vehicle is its weight. However, simply replacing heavier materials, such as steel, with lighter ones, which may be more energy-intensive to produce, have a higher environmental impact or are less recyclable at the end of the vehicle's life, is not conducive to conserving resources. In order to avoid false incentives for lightweight construction by limiting vehicle weight, vehicle dimensions are better suited to providing a reliable, easily verifiable criterion for resource utilisation. The vehicle's space consumption (e.g. parking) is also taken into account this way.



Material-specific recycled content targets

Recyclate utilisation quotas and the obligation to disclose the recycled content for selected materials are proposed as drivers for the market for high-quality secondary raw materials and the development of corresponding recycling capacities. These include steel, battery materials in accordance with the EU Battery Regulation (European Parliament, Council of the European Union 2023), plastics and rare earth elements.



Battery capacity

In order to limit the use of materials in traction batteries, some of which are classified as critical, it is proposed that the maximum battery capacity for the respective vehicle utilisation class be limited.

[1] Future criterion for as soon as calculation standards are set



Energy consumption in use

In order to prevent energy consumption from increasing indefinitely after the transition to electromobility with renewable energies, it is proposed to limit the maximum permissible energy consumption in use (according to the WLTP protocol and additionally taking into account auxiliary consumers, such as air conditioning).



Modular design

Repairability and upgradeability are important aspects that contribute to the longevity of a vehicle. This is often limited by the fixed installation and therefore very time-consuming replacement of defective parts or the inability to replace outdated components. In addition, a modular vehicle structure promotes dismantling capability and thus recyclability at the end of a vehicle's life. For this reason, a list of parts is proposed (link to final report) that are replaceable in a reasonable amount of time and with conventional tools.



Due diligence in supply chains

It is proposed that compliance with the due diligence obligations in the supply chains in accordance with the EU Supply Chain Directive be required of the manufacturer not only for direct suppliers, as provided for therein, but also for indirect suppliers.



Provision of spare parts and software updates

To further support reparability and longevity, it is proposed to require manufacturers to guarantee the availability of software updates and spare parts for at least 20 years (in a similar way to the European ecodesign requirements for washing machines (European Comission 2019), for example).



Lifetime warranty for traction batteries

For the traction battery, it is proposed that the manufacturer provides a lifetime warranty. This should cover the preservation of a certain amount of the original battery capacity for at least 300,000 km or 20 years.

2.1 Future criteria

In addition to the criteria mentioned above, two more were identified which, according to the project results, would make an essential contribution to greenhouse gas savings and resource conservation, but which cannot yet be verified in a standardised manner. We therefore recommend that the standardisation of the determination methodology be driven forward and that maximum values be subsequently defined as criteria.



Product Carbon Footprint

With the transition towards electromobility, greenhouse gas emissions in other vehicle life cycle phases are becoming increasingly relevant alongside those of the utilisation phase. Limiting the emissions of battery electric vehicles therefore requires a criterion that takes the manufacturing phase into account. The CO_2-footprint or Product Carbon Footprint (PCF) is a suitable criterion here. However, the standardisation of the determination methodology for this is still in progress, so that concrete values can only be defined in the future.



Raw materials index

Although restricting vehicle dimensions instead of weight avoids false incentives for lightweight construction, it does not take into account various aspects in addition to the pure amount of material, such as the distinction between primary and secondary raw materials, the manufacturing process and other specific environmental impacts. The ideal criterion for the raw material consumption of a vehicle is therefore a raw materials index in which these aspects are considered and weighted individually.

As there is no (internationally) standardised methodology for this type of index, in "AutoRess" further scientific analysis of the topic and the development of such a standard are proposed.

3 User Profiles

To determine the maximum values for the various criteria, different user profiles were defined to reflect the different user requirements for cars. These specify how many people and how much luggage are transported in the main use case and whether the vehicle is used for short or long journeys. The resulting user profiles and their minimum requirements in terms of space and range can be found in Table 2.

Maximum values were proposed for the various usage profiles for already quantifiable criteria such as vehicle size, battery capacity and energy consumption (see Table 3). For this purpose, the values for approx. 400 electric cars already available on the German market were analysed and value suggestions were made based on the models to be classified in the respective user profile.

Table 2: Characterisation and minimum requirements of the defined user profiles

User profile	Seats	Prevailing mode of usage	Range (WLTP)[2]	Transport capacity
City(2)	2	Urban environment (up to 50 km/h)	200 km	0
Family(5)	5	Urban and suburban environment, Motorways	500 km	ca. 600 l
Transport(9)	up to 9 or especially bulky luggage	Urban and suburban environment, Motorways	500 km	ca. 1500 l

[2] Worldwide Harmonised Light-Duty Vehicles Test Procedure

4 Implementation of Criteria

There are various approaches to implementing the proposed criteria for resource-efficient vehicles. On the one hand, central criteria should apply as minimum requirements for all or at least most electric vehicles registered in the future; on the other hand, stricter criteria can also be imposed on certain subsets of vehicles, e.g. for an environmental label. Table 3 summarises the proposed values for vehicle and battery size as well as energy consumption for the various conceivable requirement levels. The time frame in which the respective criteria are introduced depends heavily on the respective associated measures.

Level 1: Basic requirements for as many electric vehicles registered in the future as possible

The greatest leverage results from the proposed criteria if they apply to as many vehicles registered in the future as possible. There are various (legal) anchoring options for this, which are suitable for the integration of different criteria to varying degrees. Since no binding influence can be exerted on the purchasing decisions of private customers, the anchoring options here tend to be on the supply side or incentivise buyers to opt for more resource-efficient vehicles. For the user profile-specific criteria, for example, a different level of taxation or eco-modulation of vehicles purchased in an organisation would be an option.

Criteria such as recycled content targets and PCF, which require a standardised calculation methodology and should be binding for every vehicle placed on the market in the future, can be anchored directly in the corresponding regulations concerning vehicle registration.

Level 2: Demanding. Example: Preferential public procurement

The procurement of vehicles for public institutions represents a not insignificant market share, the advantage of which is that, in addition to the supply side, the purchasing decision is also actively influenced. Green public procurement in the European Union in general is already addressed in Comission's Circular Economy Action Plan (European Comission 2020). In addition, the Revised Clean Vehicles Directive (European Parliament, Council of the European Union 2019) and the Green Public Procurement Criteria for Road Transport (European Commission 2021) pose criteria specifically for vehicles. These currently relate almost exclusively to exhaust emissions. In a future version, the resource conservation criteria proposed in the previous section and specified in Table 3 in the 'Public procurement' column could also be integrated here. The verification process can be organised as follows:

- Length/width according to registration certificate
- Battery capacity: Battery passport according to (European Parliament, Council of the European Union 2023)
- Energy consumption: Manufacturer's specification according to WLTP protocol

In addition, the purchase according to the minimum requirement plays an important role here. The first tools for determining requirements are already available at least in Germany[3] and could be expanded and utilised further.

Level 3: Environmental label for particularly resource-efficient vehicles

The introduction of a corresponding environmental label would be appropriate to recognise vehicles that stand out due to their particular resource efficiency and greenhouse gas reduction.

[3] E.g. https://www.nachhaltige-oeffentliche-pkw-beschaffung.de/

This might best be implemented on an EU level, as vehicles are often exported in other European countries at some point of their service life. Thus, passenger vehicles could be integrated in a new category in the European eco-label (European Comission 2025). Another option would be to implement the proposed criteria in existing federal or local environmental labels like e.g. the German Federal Environmental Agency's „Blauer Engel" (Umweltbundesamt, Bundesministerium für Umwelt, Klimaschutz, Naturschutz und nukleare Sicherheit 2025) or the Nordic Council's „Nordic Swan" (Nordic Council 2025)

As those are ambitious eco-labels and the labelled products should be groundbreaking for future development, the suggested values were based on the best cases of vehicles currently available on the market. Ambitious values can also be set here for the other criteria such as recycled content targets and product carbon footprint.

Table 3: Proposed maximum values for the criteria of size, battery capacity and energy consumption for the various user profiles and ambition levels for a resource-efficient vehicle

Ambition level	**Basic**			**Public Procurement**			**Environmental label**		
User Profile	1 City	2 Family	3 Trans-port	1 City	2 Family	3 Trans-port	1 City	2 Family	3 Trans-port
Length/Width [mm]	3700 x 1650	4740 x 1930	5200 x 2200	2740 x 1480	4650 x 1900	5000 x 1980	2390 x 1320	4500 x 1850	4980 x 1920
Battery capacity [kWh]	22	88	130	18	70	100	12	65	95
Energy consumption [Wh/km]	110	17	260	90	140	200	60	130	190

Compliance with the criteria by vehicles currently available on the market

The key criteria of vehicle size, battery capacity and energy consumption are already easy to determine and verify today and are provided by the manufacturer for every vehicle on the German market.

User profile City(2) (2 seats for journeys in an urban environment) is virtually unrepresented within the M1 vehicle class. Almost all vehicles on the market have 4 seats and are therefore larger than the maximum values proposed here.

In vehicle classes L7e and L6e (electric light mobility), however, it is clear that further space can be saved by dispensing with unused seating and transport capacity as well as certain comfort features. The models analysed here all meet the minimum requirements for user profile City(2). Compliance with the criteria for battery size and energy consumption is similar. Here too, however, it can be assumed that a reduction in vehicle size makes lower energy consumption and thus battery size technically possible and that in this case there is mainly a lack of offers.

User profile Family(5) is based on the D(large) categorization within European categorisation scheme for M1 vehicles. Of these, around 70% already fulfil the criteria for battery capacity and energy consumption, while only around 30% meet the minimum requirements for maximum size. In addition, around 20% of the entire vehicle fleet in Germany consists of the 'luxury' and 'SUV'

segments, which were not included in the value calculation as they have no additional functionality in contrast to user profile Family(5). These do not fulfil the required maximum values to a large extent.

In user profile Transport(9), the number of all-electric vehicles on offer has so far been very limited, which is why the value range of the existing models is quite narrow here. As the feasibility of stricter criteria could not be clearly established here, all of the models on the market initially fulfil the basic requirements.

Background

The information summarised here reflects the results of the project 'AutoRess' - Resource-conserving and circular economy-capable motor vehicles: Instruments and measures to reduce the demand for raw materials in the transport sector through circular economy parallel to an energy transition in transport" (FKZ 3722 57 101 0) in relation to criteria for resource-efficient vehicles. In the course of the project, technical and non-technical options for reducing the impact of transport on climate and resource consumption were analysed across all vehicle life cycle phases. Based on this, suitable instruments and measures were developed and evaluated, which were combined to create a Circular Economy Roadmap for vehicles.

The project was carried out by the Oeko-Institut e. V. together with ifeu gGmbH, Mehlhart Consulting and team ewen.

Duration: November 2022 to August 2025

5 Literature

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