Passenger Cars Driven on Hilly Roads in Austria

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Previous studies of road or railway infrastructures have shown that traffic emissions outweigh the environmental impacts of the product stage and construction stage over the entire life cycle. Traffic usage is therefore the main emitter over the life cycle (A1–C4). Due to the small number of sustainability assessment systems, the question of how to consider traffic emissions in detail in an integral life cycle assessment has arisen.

Keywords: cars driven in Austria ; infrastructure ; integral LCA studies ; life cycle assessment

1. Introduction

Accounting for approximately 37% of global greenhouse gas emissions, the construction industry has a significant impact on the environment, the consumption of energy and the use of natural resources [1]. In view of new regulations at the European and national levels [2], and increased efforts towards sustainability, it is necessary to accurately quantify the emissions of new construction projects and maintenance measures over the entire life cycle (A1–C4).

The life cycle assessment (LCA) of buildings, but also of infrastructures, is becoming increasingly important in society and for decision-makers [3]. For the infrastructure sector in particular, the small number of standardized assessment systems has resulted in difficulties with the data basis and implementation [4]. With regard to the implementation of analyses, it should be noted that the lack of infrastructure assessment systems [3][4][5] often results in labor-intensive and costly individual studies. Current research is attempting to close the “markets gap” and develop life cycle tools [3][4][5].

When investigating the emissions of road infrastructures over their whole life cycle (A1-C4), i.e., from the production of materials (A1–A3), transportation to the site (A4), construction (A5), maintenance (B2–B8), to dismantling and disposal (C1–C4), it is essential to consider the direct operational emissions from traffic use (B1) of the infrastructure. In addition to the emissions generated by construction and the materials used, previous studies have shown that these are only marginal compared to the operating emissions generated over the entire life cycle [6][7]. In other words, traffic/traffic use (B1) can be identified as the main emitter for traffic infrastructures. In the case of road infrastructures, these emissions can be attributed to emissions from road vehicles. However, this raises the question of which detailed and up-to-date results of traffic emissions are available and how these can be optimally prepared for integration into a life cycle assessment (LCA) or an assessment system for traffic infrastructures.

Ecological data for passenger cars are currently available on the market at the country-specific level for CO_2 values (pure CO_2 and CO_2 equivalents—abbr.: eq.) and particulate matter (PM) from various established assessment systems [8][9][10][11]. As these data are not sufficient for an integral LCA of a traffic infrastructure according to EN17472 [12], further investigations are required that consider other environmental impact indicators beyond the values of CO_2 and PM, according to ÖNORM EN15804 [13]. In addition to the results on air pollutants from the aforementioned assessment systems, eco-data are partly available from databases (e.g., ecoinvent) [14]. However, these only cover current vehicle populations and current technology standards (e.g., vehicle masses, battery sizes of electric cars, mileage, etc.) to a limited extent. In addition, the datasets in the databases are usually only targeted for larger regions (e.g., Europe, global, etc.) and cannot be further assigned to specific countries [14]. Similarly, no particular route specifics and route gradients can be taken into account in a detailed form in the sustainability assessment of the road infrastructure, as the currently available emission values only cover the average journey in the plain.

The investigated results for the life cycle stage “B1 use” can be included in an integral LCA of a traffic infrastructure; therefore, holistic considerations, such as route variants (e.g., tunnel vs. mountain pass road), detour traffic or traffic scenarios, can be quantified in detail. This will make a further contribution to a more detailed consideration of the environmental effects of the use of road infrastructures (B1) and thus support future sustainable decision-making and, above all, the implementation of a future sustainable built environment.

2. Sustainable Goals and Problems of Traffic

In fulfilling the climate objectives of the United Nations [15] and the European Commission [2], as well as in managing the transition to sustainable energy, the transportation sector, and particularly motor vehicle traffic, has a significant and presently notable impact on politics and media [16]. In light of the United Nations Environment Program—Global Status Report 2022 [1], it is clear that the transportation industry contributes 22% [1] of the world's greenhouse gas emissions and faces the challenge of contributing to climate change mitigation [16]. Currently, policymakers in Europe and Austria [2][16][17] are prioritizing the replacement of internal combustion engine cars (ICE) with battery electric vehicles (BEVs) [16]. By 2030, newly registered cars in Austria must be "emission-neutral" in accordance with the regulations of the Austrian federal government [17]. The changeover is viewed positively in terms of environmental friendliness by transport experts, as per a report by the Austrian automobile club ÖAMTC [16]. However, there are still concerns about range deficits and high costs associated with e-cars in comparison to traditional combustion engines [16]. On the flip side, the long charging times and inadequate charging infrastructure detract from the benefits [16]. To achieve a sustainable transition towards mobility, the focus must be on the technological advancement [16][18] of a fuel-efficient and emissions-neutral means of transportation. Nonetheless, setting up the requisite charging infrastructure is also crucial [16].

3. The Austrian Car Stock

When looking at the Austrian vehicle stock [18][19][20][21], it becomes clear that cars with internal combustion engines (ICE) are widely used in Austria. Approximately 94% (according to the data collection of 31 December 2022) [19] of the Austrian car stock are cars with pure diesel or petrol engines. The remaining 6% comprises hybrid (HEV) or plug-in hybrid vehicles (PHEV) with petrol/electricity (2.9%), electric cars (BEV) (2.1%), diesel/electric cars (0.8%) and about 0.1% natural gas (NG) cars [19][20] (see **Figure 1**).

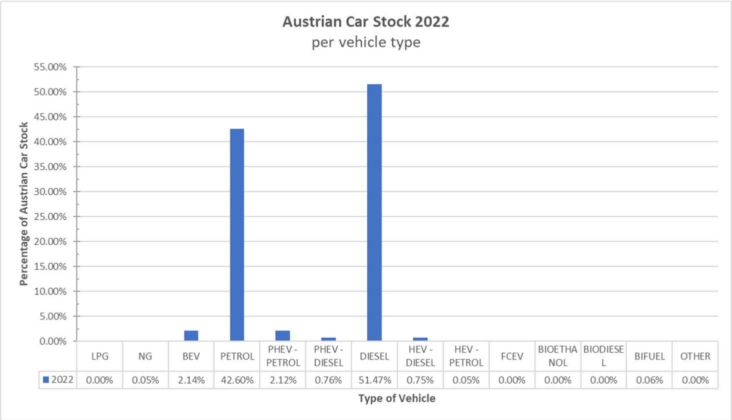

Figure 1. The Austrian car stock for the year 2022 per vehicle type.

By analyzing the development of the Austrian vehicle population, clear trends can be identified [18][19]. For instance, the diesel combustion engine (ICE diesel), which has enjoyed widespread popularity in Austria for many years, has been losing ground since 2018. A drop of 4.5% in diesel-powered vehicles can be attributed to the diesel emissions scandal [16]. Conversely, significant growth rates have been observed for alternative drive systems. The number of battery electric vehicles (BEVs) in Austria has surged from 3386 in 2014 to 110,225 in eight years [18][19]. Nevertheless, hybrid electric vehicles (HEVs) with both a combustion engine and an electric range are currently in high demand. Plug-in hybrid electric vehicles (PHEV), which are hybrids that can recharge externally through a power socket, are particularly popular at present [18][19] (refer to **Figure 2**). Other alternative driving systems, such as LPG cars and hydrogen or fuel cell cars (HYD_FCELL), have seen a slight increase in numbers. However, there is no significant volatility in the population of cars in Austria in total.

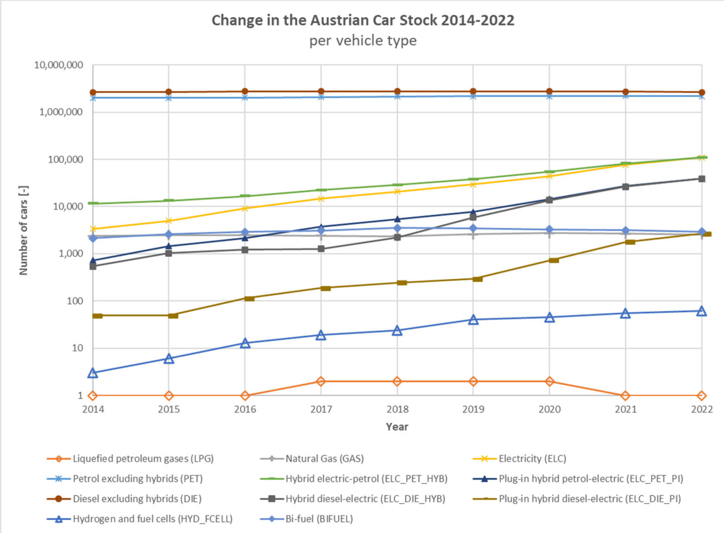

Figure 2. The numerical changes in the Austrian car stock per vehicle type from 2014 to 2022.

In order to determine the vehicle population in Austria, the age distribution of the vehicles on the roads is essential. This is particularly significant for cars with combustion engines as the date of manufacture corresponds to European emission classes (EURO classes). Due to the amounts of emissions released into the air, these EURO classes are decisive for a subsequent life cycle assessment (LCA) and integral LCA implementation. The Austrian Federal Statistical Office [19] recorded the age structure of passenger cars in Austria. Following the guidelines of the European Union [22] and using the known dates of manufacture from the vehicle registration information [23], the vehicles can now be assigned to specified EURO emission classes [22][24]. For cars in Austria, approximately 19% were assigned to EURO 3, 12% to EURO 4, 29% to EURO 5, and 40% to EURO 6 emission classes.

Based on the current inventory of vehicles, the LCA for various passenger cars can now considered for a life cycle assessment (LCA) integration of a traffic infrastructure. However, the question arises as to how to evaluate the vehicles from an ecological point of view, and which evaluation system (e.g., HBEFA, TREMOD, TREMOVE, COPERT etc.) [8][9][10][25][26][27] or database (e.g., ecoinvent etc.) [14][28] should be used. In the following, the results of the life cycle assessment will be regarded and discussed.

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