# MobiLab2.0: Scientific support in sustainable mobility and logistics solutions

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# MobiLab2.0: Scientific support in sustainable mobility and logistics solutions

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**Abstract:** Since its establishment in 2017, MobiLab2.0 (former MobiLab Upper Austria) has been working with companies and institutions in its advisory role as a project developer, facilitator, and evaluator to successfully get innovative, novel approaches into action. To ensure a high standard of this implementation, it is necessary to implement the projects in a scientific framework. This paper presents the difficulties of the topics dealt with in the living lab to reflect scientifically and to put them into the context of global/European developments. The two topics *identification of a sustainable fleet and the necessary infrastructure* and *sustainable last-mile logistics* dealt with in the Austrian Living Lab *MobiLab* are examined in terms of their difficulties and opportunities and considered in the context of scientific work.

**Keywords:** Sustainability, Sustainable Mobility, Sustainable Last-Mile-Logistics, Climate Change, Scientific Research, Living Lab

## 1 Introduction

The need for sustainable mobility and logistics concepts is strong among all stakeholder groups due to the European emission reduction targets in the transport sector, which were set as part of the European Green Deal. The transport sector emits more greenhouse gases than any other industry - including electricity production and agriculture1 and accounts for around a quarter of all energy-related carbon dioxide emissions.[2,3] The imbalance between

[1] J. Timperley, "Private transport is one of the world's biggest sources of greenhouse gases, with emissions rising every year. In our car dominated cities, can we cut down the carbon footprint of our daily commute?," https://www.bbc.com/future/article/20200317-climate-change-cut-carbon-emissions-from-your-commute?msclkid=c12a59aac53f11eca19574527a5fa6a8, accessed April 2022.
[2] H. Ritchie, "Cars, planes, trains: where do CO2 emissions from transport come from?," 2020, https://ourworldindata.org/co2-emissions-from-transport.
[3] Wang, S., & Ge, M., "Everything you need to know about the fastest-growing source of global emissions: Transport.," 2020, https://www.wri.org/insights/everything-you-need-know-about-fastest-growing-source-global-emissions-transport.

supply and demand in the urban transport system is becoming evident, especially because of the lack of land resources and environmental capacity. These circumstances further increase urban traffic, reducing average vehicle speed, increasing accident numbers and pollution.[4]

Today, traffic is responsible for around 30 percent of greenhouse gas emissions in Austria. Private motorized transport (MIV), freight and air traffic are responsible for high pollution levels of particulate matter, nitrogen oxides and other air pollutants such as ground-level ozone, noise pollution, land consumption and accident costs. A series of measures regarding sustainability in transport have already been successfully implemented, but the turnaround to an environmentally friendly transport system, in particular with the greatest possible use of renewable energies, has not yet been achieved. Austria will therefore step up its efforts to pursue an environmentally and socially compatible transport policy to reverse the persistent unsustainable trends in transport. To achieve a sustainable and climate-friendly transport system in the long term, the use of renewable energies, such as sustainably produced biofuels and e-mobility with electricity from renewable energy sources, as well as a shift to environmentally friendly modes of transport, such as rail and ship, soft non-motorized mobility, and improved information and communication systems for better traffic control and use of transport infrastructure are necessary.[5] Expertise of mobility experts must be used to develop tailor-made solutions as far as possible and thus improve the output. Evaluation processes must be clearly defined to be able to present corresponding (interim) results and determine whether the objectives have been achieved.

Austrian Mobility Labs build on ideas and methods associated with the concepts of "living labs" and "real-world laboratories". Both Living Labs and real-world laboratories came into being because in the past, numerous promising solutions - not only in the field of mobility - were developed, but in too many cases not implemented accordingly and forgotten. Thus, many innovations never met people and their actual needs.[6] Accordingly, Austrian Mobility Labs support research & development to maximize their potential in a real-world setting where both science and practice can work together at eye level. People with different backgrounds can improve innovations together and finally test if their solution can pass the practical test in everyday situations. At its core, they are a platform for people to work together to let a more sustainable, affordable, and inclusive transport mobility system become a reality.[7] MobiLab2.0 is embedded at the University of Applied Sciences Upper Austria and can thus use and share resources in a scientific context. In this study, we would like to present our Upper Austrian Living Lab with its core topics and explain in more detail our scientific support on the topics "Sustainable last mile logistics" and "Identification of a sustainable vehicle fleet and infrastructure", addressing problems and opportunities in the implementation.

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[4] Umweltbundesamt, "Klimaschutzbericht 2021," 2021, https://www.umweltbundesamt.at/fileadmin/site/publikationen/rep0776.pdf, accessed April 2022.
[5] Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie, "ÖSTRAT-Österreichische Strategie Nachhaltige Entwicklung Arbeitsprogramm 2011ff des Bundes und der Länder," 2011, https://www.bmk.gv.at/dam/jcr:bd3c35a6-29e1-46e6-ab0b-99aa2f39ab1e/OeSTRAT_Arbeitsprogramm_2011.pdf?msclkid=3c931072c5fd11ec926612cc53fcc946, accessed April 2022.
[6] *BMK* (2022), https://mobilitaetderzukunft.at/de/artikel/mobilitaetslabore/?msclkid=ae755f23c6f911ec955344d1e4730c98.
[7] Ibid.

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## 2 MobiLab2.0 - Upper Austrians Mobility Lab

MobiLab2.0 is a user-centered, multidisciplinary innovation laboratory that has been working on central mobility topics related to passenger and freight transport in the Upper Austrian region since its founding in 2017, most of which arise because of economic factors. MobiLab2.0 operates in the so-called central region of Upper Austria, which includes Linz, Steyr and Wels. In the area of personal mobility, the topics addressed include work-related traffic (with a focus on inter-company mobility management), business travel, and customer and visitor traffic. In the area of goods mobility, the focus is on delivery, production, and distribution transport, including waste disposal. Through its further function as a hot spot for future-relevant mobility innovations, MobiLab2.0 supports cities, municipalities, regions as well as companies and start-ups in the development, testing and implementation of new, sustainable mobility and logistics solutions. MobiLab2.0 has the possibility to develop and test different tools and methods to direct the focus on new, innovative sustainable ideas.

Four main themes have been identified as a framework for research in innovative areas and for putting the results obtained into practice. (1) Intercompany mobility management deals with the integration of sustainable forms of mobility at company sites (i.e. promotion of carpooling and public transport), which is expected to have positive effects for company locations, their employees and the environment (reduction of emissions, congestion and noise). (2) Sustainable last mile logistics provides new products, services, and the necessary suppliers with last-mile concepts for established economic and industrial regions to reduce environmental impacts and to promote regional value creation. (3) The identification of a sustainable vehicle fleet and the necessary infrastructure addresses the need for new technologies in the transport sector and provides clear information to all stakeholders on the technical feasibility, environmental impact, and costs for alternative technologies. (4) Logistics space optimization considers societal goals, environmental goals, and business goals in the sustainability assessment of potential logistics sites to help identify the most suitable location for freight transportation and logistics, thereby reducing environmental impacts and congestion on existing infrastructure.

MobiLab2.0 pursues a strategy of generating mobility innovations in a structured manner for current mobility problems without a predefined solution and supporting the implementation of these innovations. The structure and content of the MobiLab2.0 topics should make it possible to transfer these topics to other cities or regions. The two topics of sustainable vehicle fleet and sustainable last-mile logistics are discussed in more detail in this paper, and difficulties and opportunities for future areas of application are discussed. In the environment of MobiLab2.0, these topics are of particular interest, as MobiLab2.0 is very strongly networked in the Upper Austrian industry and thus several stakeholders as well as MobiLab2.0 itself benefit from scientific research.

## 3 Identification of a sustainable fleet and the necessary infrastructure

A transition of the vehicle fleets in freight and passenger transport is essential to achieve the target of 90% emission reduction by 2050 set in the European Green Deal.[8] From 1990 to 2019, emissions from transport in Austria increased by 10.2 million tons of $CO_2$e, which

[8] *The European Green Deal: COM(2019) 640 final* (2019), https://ec.europa.eu/info/sites/info/files/european-green-deal-communication_en.pdf, accessed April 2022.

corresponds to an increase of 74.4%. Freight transport in Austria was responsible for 11% of total emissions in 2019 and public passenger transport for 18.7% emissions.[9] Both areas thus offer great potential for emissions savings, which will be achieved through traffic avoidance, modal shift, and transition to vehicle fleets with alternative drive concepts.[10]

Fleet conversion offers numerous benefits in addition to the environmental benefits:

- **Improving operational efficiency and reducing associated costs:** Conversion to zero-emission vehicles can avert significant costs in the medium and long term due to steadily rising diesel fuel prices.
- **Reduced risk from climate and air pollution-related risks and regulations:** Future costs from governmental climate regulations such as $CO_2$ taxation can be avoided. Furthermore, investors will increasingly demand disclosure of carbon footprints and climate actions from companies in the future.
- **Increased customer satisfaction:** Customers are increasingly paying attention to the sustainability of products and services. $CO_2$-neutral supply chains can be a strong purchasing criterion and strengthen the company's brand awareness and market share.
- **Improved image of the company in the public and civil society:** Companies make an important contribution to limiting environmental and climate impacts through an emission-free fleet and thus contribute to the Paris Agreement and the Sustainable Development Goals (SDGs).
- **Attractiveness of the company for employees increases:** Company identity plays a key role in career choices, especially among younger generations who identify strongly with the company's values. Companies that are more committed to the environment are significantly more popular potential employers.

### *Difficulties in identifying sustainable fleet concepts*

For successful implementation, numerous questions must be answered in advance to achieve the most efficient solutions possible. First, the question must be clarified as to which alternative drive concepts are relevant for a fleet conversion to achieve corresponding emission savings. A closer look at this topic reveals that this question cannot be answered simply across the board, but must be considered specifically depending on the use case. The currently favoured low-emission fuel vehicle concepts CNG/LNG, biofuels, electric vehicles, and fuel cell vehicles offer advantages and disadvantages, which must be considered accordingly when examining their relevance. In road freight and passenger transport, a switch to electric drives and fuel cell drives is intended to bring about the necessary turnaround in the climate impact of transport emissions to achieve the set national and international emission reduction targets.[11] Whether this is possible must be considered specifically for each application.

[9] Umweltbundesamt, “Klimaschutzbericht 2021,” 2021, https://www.umweltbundesamt.at/fileadmin/site/publikationen/rep0776.pdf, accessed April 2022.
[10] BMK, “Austria’s 2030 Mobility Master Plan: The new climate action framework for the transport sector: sustainable - resilient - digital,” 2021, https://www.bmk.gv.at/dam/jcr:eaf9808b-b7f9-43d0-9faf-df28c202ce31/BMK_Mobilitaetsmasterplan2030_EN_UA.pdf, accessed April 2022.
[11] Ibid.

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First and foremost, the technical feasibility of a fleet conversion to alternative drive concepts should be examined, depending on the area of application. The range of electric vehicles and fuel cell vehicles is significantly below the range of conventional diesel vehicles, especially in the heavy-duty sector (buses and heavy-duty trucks). Therefore, it must be examined whether previous operating profiles can be adopted at all or must be adapted accordingly. The availability of vehicles with alternative drive systems defines the time frame of the fleet conversion and is strongly dependent on the supply and demand of vehicles with alternative drive systems. Due to the current and future cost increase for diesel vehicles due to rising diesel fuel prices, $CO_2$ tax and further charges, a strong demand for alternative concepts is to be expected. The difficulty here will be the corresponding growth in vehicle production to meet this demand.

As a further step, the financial feasibility and the ecological benefits of a fleet conversion must be examined. The financial feasibility is currently strongly linked to subsidies for the procurement of vehicles with alternative drives and the associated charging infrastructure to reduce the high investment costs accordingly and thus facilitate the market entry of new technologies. In addition to the investment costs, variable costs such as fuel and energy costs, maintenance costs and toll costs must be considered for the respective area of operation and compared at regular intervals. The environmental benefits of low-emission fuel vehicle concepts depend heavily on the emissions generated in energy production and supply (well-to-tank emissions). Electric or fuel cell concepts are often referred to as emission-free due to no $CO_2$ emissions occurring during operation. However, a closer look at the origin of the electricity or hydrogen reveals that this assumption is only true if electricity from renewable energy sources (green electricity) is used to operate the vehicles. Conversion of the vehicle fleet thus also necessarily requires addressing the provision of a corresponding infrastructure for energy generation and supply.

Mobilab2.0 has addressed these aspects in the context of a business case regarding a fleet conversion to fuel cell buses for selected regions in Salzburg. Selected results of this study shall explain how a current overview of the status quo can be created to scientifically support bus companies in the fleet conversion.

## *Business case of a fleet conversion to $H_2$ buses*

The following selected results are intended to illustrate how the addressed aspects of technical and economic feasibility as well as environmental benefits for a fleet conversion in a specific region can be presented to subsequently serve as a basis for further planning of the fleet conversion by the bus operators.

## *Technical feasibility*

An overview of the fuel cell bus models available on the market was created to obtain an overview of the technical data of the current market offering. As of November 2021, a total of 19 fuel cell bus models from 14 manufacturers were available on the market. The wide range of driving power (electric engine, fuel cell, battery) shows that a wide variety of models for different operating profiles are already available. In terms of passenger capacity and vehicle length, the available fuel cell bus models correspond to the equipment of conventional buses and can thus take over their previous operating profile without any problems. The range spectrum of the buses is 200-650 km, with a range between 300-400 km reported for most of the models.

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The following bar chart shows the maximum daily kilometres of the 15 diesel buses in the region under consideration in Salzburg. The number of kilometres driven daily by the buses can vary depending on the day type (Mon-Fri/school operation, Mon-Fri/holidays, Saturday, Sundays and holidays). For this reason, the longest daily profile of each bus was used for the technical feasibility review. 13 buses have a circulation length of less than 300 km and can therefore be replaced by a large proportion of the currently available fuel cell buses without any problems. These buses are represented in the diagram by the designation "minimum range $H_2$ standard bus". There are also several $H_2$ bus models for the remaining two circulation lengths of 335 km and 364 km, which have a sufficient range profile to be able to operate these bus routes without a refuelling stop (e.g. bus models from Caetanobus, Wrightbus, Hyundai or New Flyer).

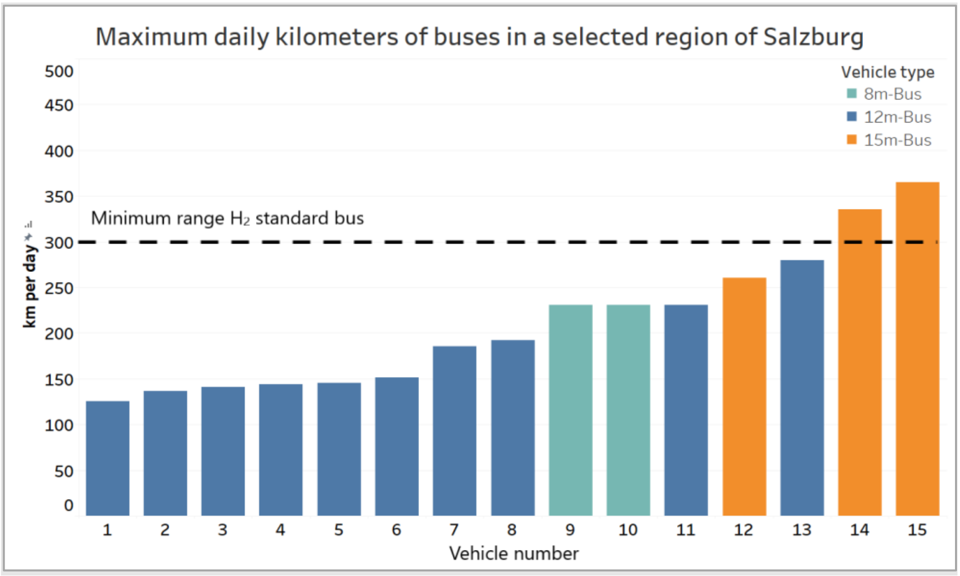


**Figure 1: Maximum circulation length of buses in a selected region of Salzburg**

For the traffic region under consideration, a conversion of the fleet would thus be easy in terms of technical feasibility since the previous operating profiles of the conventional diesel vehicles can be adopted. This eliminates the additional effort of a new adapted route planning and any additional costs due to more vehicles and drivers, which would be required for lower ranges. In addition, a central charging infrastructure is sufficient. For shorter ranges, such as battery-electric buses, additional decentralized or mobile charging infrastructures would have to be created if the operating profiles were maintained.

### *Financial feasibility*

The following diagram compares the total cost of ownership per year of a diesel bus fleet (ICE) with an $H_2$-bus fleet (FCEV) for the considered region of Salzburg. Based on the results of the technical feasibility, the same operating profile and the same number of vehicles are assumed for both fleets. Thus, both fleets have the same labour costs and overheads, which were therefore not considered in this comparison. Since the refuelling infrastructure costs in this use case are provided by third-party suppliers, it was assumed that these costs were included in the fuel prices accordingly. For the vehicle prices for $H_2$-buses, 80% of the additional investment costs were deducted according to the current funding possibilities.[12]

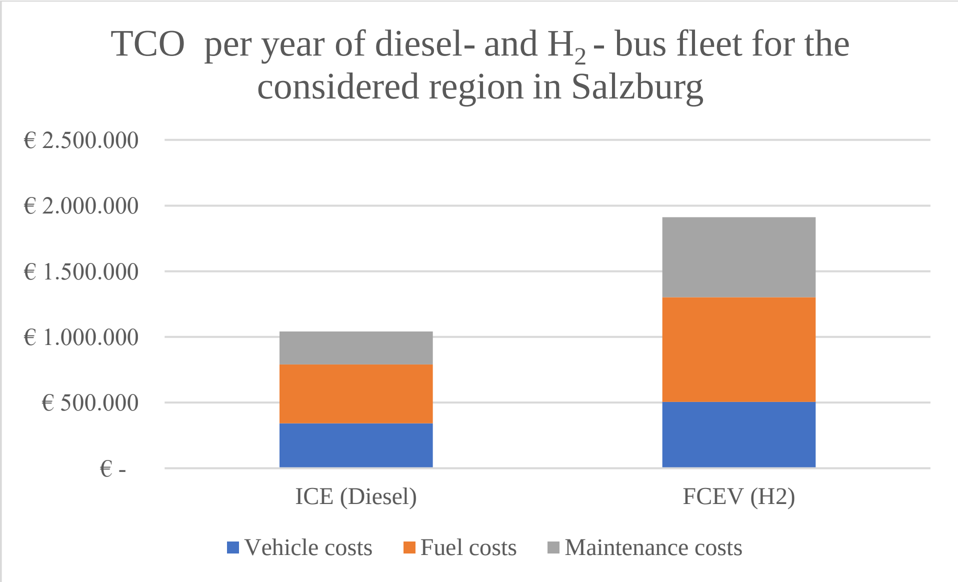


**Figure 2:** TCO of diesel- and H2-bus fleet for the considered region in Salzburg

Based on the TCO comparison, it can be determined that approx. 84% additional costs are to be expected for the operation of $H_2$-buses in the region under consideration. The new subsidy options for the acquisition of the $H_2$-fleet lead to a significant reduction of the additional investment costs and thus considerably facilitate the market entry of this technology. However, fuel costs still represent a considerable additional cost factor of almost €350,000 per year (+80%) in the use case considered as of the end of 2021. In addition to the fuel costs, a high cost difference can also be seen in the maintenance and servicing costs. This is due to the fact that the cost rates used are full-service contracts and the replacement of various $H_2$-bus-specific components (e.g. battery or fuel cell) is included in these cost rates, which have to be replaced or regenerated and overhauled due to the long service life of the buses.

### *Ecological benefit*

The following diagram illustrates the necessity of including emissions in energy production and supply (well-to-tank emissions) when considering alternative drive concepts using the given example of an $H_2$-bus fleet. If green hydrogen is used for operation, more than 1,000 tons of $CO_2e$ per year (-93%) can be saved compared to a conventional diesel fleet. In the case of blue hydrogen, $CO_2e$ savings of 38% or 59% can be achieved through carbon capture and storage (CCS) and depending on the production process. For grey hydrogen, the $CO_2e$ values are already +14% above the diesel value due to the lack of a CCS process.

[12] FFG, “EBIN - Emissionsfreie Busse und Infrastruktur 2021 BIS 2026: Förderprogramm zur Umstellung von Busflotten auf emissionsfreie Antriebe,” FFG, 2021, https://www.ffg.at/EBIN, accessed December 2021.

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The fact that hydrogen generated by electrolysis must necessarily be produced with green electricity is made clear by the last comparative value, which used the 2018 German electricity mix. Due to the high proportion of fossil fuels in German electricity production, this would produce almost twice as many emissions as a conventional diesel fleet.

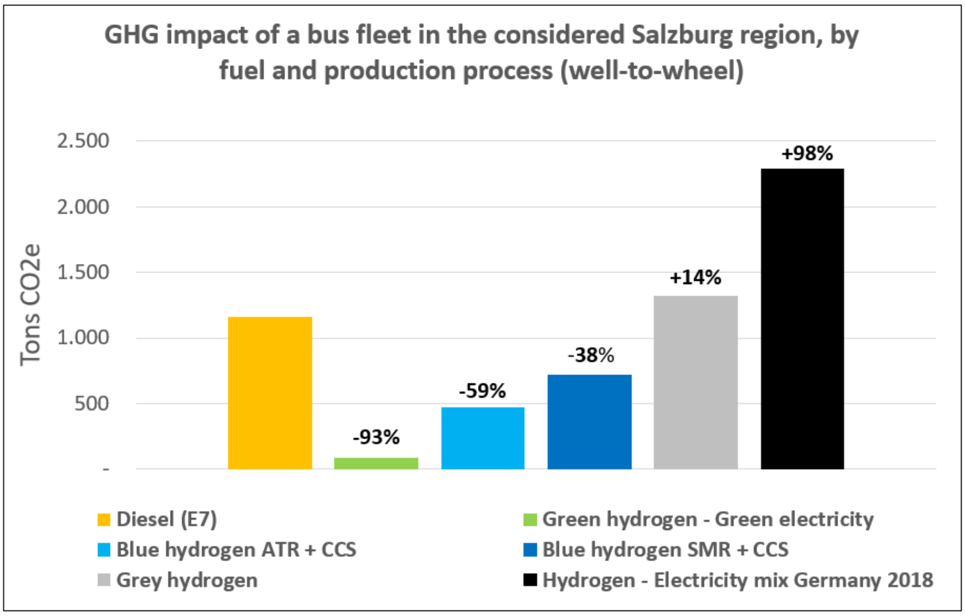


**Figure 3:** GHG impact of a $H_2$-bus fleet in the considered Salzburg region

## 4 Sustainable last mile logistics

The last mile in freight transport refers to the final stage of delivery. Generally, the term last mile is used for the end of a distribution route. This can look very different depending on the goods and the situation. The last mile is not defined by a distance that can be measured but begins with the so-called break-bulk point and ends with the customer. Increased parcel deliveries and demands from customers, the environment and capacity utilization call for alternative concepts. So, the challenges here range from reducing emissions, effectively optimizing the last mile, and successfully delivering goods, to managing land use conflicts, providing measurable freight traffic data that can be forecast, and weighing the interactions of public measures in freight traffic. In addition to the bundling of transports, the avoidance of dispensable freight transports is particularly essential for sustainable city logistics.[13]

[13] C. Heffele, “Neue Wege auf der Last Mile.,” 2018, https://www.verkehr.co.at/singleview/article/neue-wege-auf-der-last-mile.

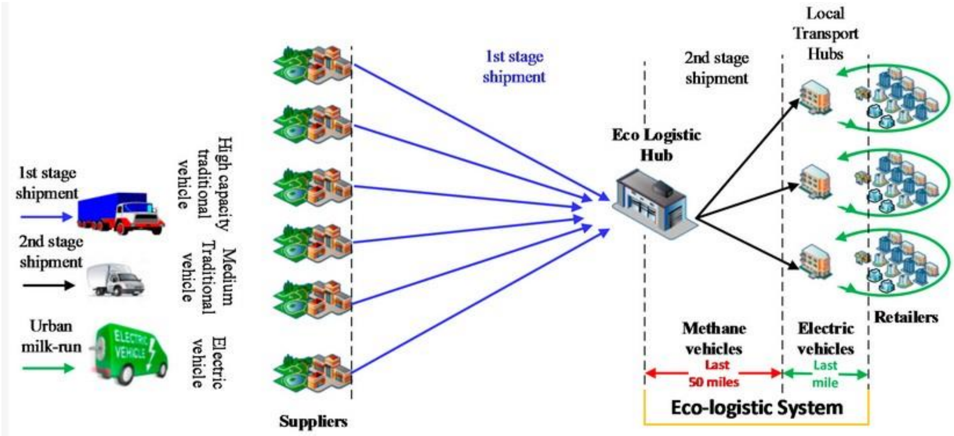


**Figure 4:** Innovative urban eco-logistic system in last mile delivery[14]

*Difficulties in the fields of last mile delivery*

In Europe, 80% of people live in urban areas. City logistics identify ways to regulate access, circulation, and the parking of commercial vehicles in urban centres and to implement policies without restrictions that harm economic and social prosperity and are conducive to relocation of economic activities and population.[15] Such logistical activities are necessary for the harmonious growth of every urban area, even if they are also the main cause of pollution, noise, and accidents. The “urban diseases” besetting modern cities are traffic congestion and environmental pollution.[16]

Furthermore, delivery processes on the last mile are very difficult to plan. On the one hand, parcel volumes are subject to strong seasonal fluctuations; before Christmas, after shopping days such as Black Friday, or during the current Covid 19 lockdowns, they are extremely high, while in summer, when many people are on vacation, they are extremely low. The delivery companies cannot orient their infrastructure to the extremes but must buy in external services for peak times.[17]

On the other hand, delays in the delivery process that can hardly be calculated are to be expected, especially in inner-city areas, due to high traffic congestion, limited parking space or incomprehensible addressing can lead to delays in the delivery process that are difficult to calculate. The fact that there are other customers to be delivered to every day also makes it difficult to plan an ideal standardized route. And finally, there is also a lot of potential for unpredictability on the part of the customers themselves. Either customers are not present at the delivery location, the delivery location was unclearly addressed or

[14] Faccio, M., Gamberi, M., “New City Logistics Paradigm: From the “Last Mile” to the “Last 50 Miles” Sustainable Distribution,” Special Issue How does Outsourcing Affect the Economy and its Sustainability? 14873-14894, 2015, https://www.mdpi.com/2071-1050/7/11/14873/htm, accessed April 2022.
[15] Dezi,G., Dondi, G., Sangiorgi, C., “Urban freight transport in Bologna: Planning commercial vehicle loading/unloading zones,” Procedia Social and Behavioral Sciences (2010) No. 2, 2010, file:///C:/Users/P42227/Downloads/Urban_freight_transport_in_Bologna_Plann.pdf.
[16] Wei, Y., Huang, C., Lam, P., Sha, Y. and Feng, Y., “Using Urban-Carrying Capacity as a Benchmark for Sustainable Urban Development: An Empirical Study of Beijing.,” 2, 3244-3268 (2015), https://www.mdpi.com/2071-1050/7/3/3244, accessed April 2022.
[17] L. S. Franke, “Das berühmte Problem der “Last Mile“ erklärt.,” 2021, https://morethandigital.info/das-beruehmte-problem-der-last-mile-erklaert/, accessed April 2022.

changed at the last minute, the customers have a very specific time window or special conditions (such as "please do not ring before 10:00") at which their parcels are to be delivered.[18]

### *Users influence on last mile delivery*

Prior to examining how last mile logistics face difficulties, it is worth illustrating the consumer group they are pivoting towards. In this section, a portrait of the urban consumer around the world is used to contextualize the environment in which internet retailers and transport operators must learn to operate.

Urban consumers today live in an increasingly populated, connected, and fast-paced environment. This provides a platform for innovation and development of services that help ease the pressure from time-consuming and mundane tasks, and help consumers to better experience the environment around them, all while bringing to light increasingly salient issues such as sustainability.

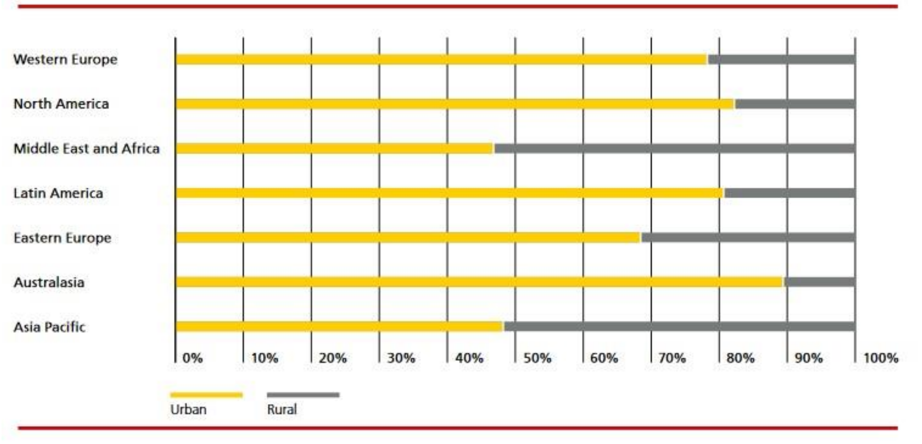


**Figure 5:** Rural/urban costumers split[19]

According to Euromonitor International, there will be an additional 1 billion people on the planet by 2030, with 60% living in an urban environment and the significant majority of them coming from today's emerging markets.[20] There will also be a 47% growth in the number of consumers aged 65+ who are healthier and wealthier than any of their predecessors in this cohort. Urban centers are ultimately projected to host more working residents with different cultural and socioeconomic backgrounds, a significant portion of which will be older and have higher purchasing power. All of this translates into a shift in preferences for daily purchases by 2030—space will be limited, so consumers will seek to centralize their tasks for the sake of convenience. This will primarily be achieved through an already growing digitization wave in society. All these trends, regardless of their

[18] L. S. Franke, "Das berühmte Problem der "Last Mile" erklärt.," 2021, https://morethandigital.info/das-beruehmte-problem-der-last-mile-erklaert/, accessed April 2022.
[19] A. Bassam, "SHORTENING THE LAST MILE: WINNING LOGISTICS STRATEGIES IN THE RACE TO THE URBAN CONSUMER," 2018, https://www.dhl.com/content/dam/dhl/local/global/core/documents/pdf/g0-core-wp-shortening-the-last-mile-en.pdf.
[20] Ibid.

location, have been driven by an increasing use of social networks to promote the user's consumption experience. Daily internet usage statistics from Euromonitor International have been on the rise globally, particularly driven by developed markets, and this expansion has been fuelled by social media becoming a key marketing tool for consumer-facing brands. Internet retail sales quintupled between 2008 and 2018, from $290.4 billion to $1.6 trillion.[21]

### *Possible sustainable solutions for last mile delivery*

Sustainable urban logistics is a new research area which aims to tackle the forementioned difficulties of last mile delivery. New technological solutions describe a technical advancement of the last mile delivery. These include other types of drive, autonomous solutions, underground tunnels, or tubes, or even drones.

### *Sustainable last mile delivery trough delivery robots and mobile pick-up points*

One trend that cannot be ignored in the future is that of robotic delivery systems and pickup delivery points. The distant future of robotic parcel delivery is already a reality today. Advances in robotics, GPS positioning, automation and navigation make it possible to deliver packages without contact, regardless of time, climate, or other influencing factors. Nowadays robots are being used everywhere from carrying out simple household work to even delivering products by delivery robots. Another possibility is to make delivery more efficient by picking up ordered goods at designated mobile pick-up points.

Most of the problems that last-mile delivery faces include damaged products, failed delivery, and increased traffic congestion. Last-mile delivery is both expensive and difficult, and it can also damage the customer's perception of the entire shopping experience. It can cost around 50% of the total shipping charges. Thus, solving the last-mile delivery problem has become essential for the logistics industry.[22] In order to solve this problem, many companies, retailers, and logistics companies have started the use of delivery robots for delivering a package to the shopper's door. Existing delivery concepts are divided into semi-autonomous and fully autonomous. The semi-autonomous concepts are mostly mobile parcel stations that are filled and set up for a certain period to be picked up again after being emptied. The Swedish product DiPPER can be cited as an example here.[23] It offers a sustainable, cost-effective and scalable last-mile delivery service. Their product is advertised with innovative power management system that turns their product into a system that never has to stop for charging, loading, or unloading. The huge capacity of the system also reduces the number of vehicles required and with fewer vehicles that can operate during hours when there is less traffic also means less congestion during peak hours. This enables continuous operation 24/7 and 20 times more capacity than what is

[21] A. Bassam, "SHORTENING THE LAST MILE: WINNING LOGISTICS STRATEGIES IN THE RACE TO THE URBAN CONSUMER," 2018, https://www.dhl.com/content/dam/dhl/local/global/core/documents/pdf/g0-core-wp-shortening-the-last-mile-en.pdf.
[22] Naveen Joshi, "The use of robots for last-mile delivery," 2019, https://www.bbntimes.com/technology/the-use-of-robots-for-last-mile-delivery#:~:text=Another%20major%20issue%20faced%20in%20last-mile%20delivery%20is,during%20non-working%20hours%20when%20there%20is%20low%20traffic.
[23] DiPP-R AB, "REINVENTING LAST-MILE DELIVERY TO SCALE WITH DEMAND," 2022, https://www.dipp-r.com/?msclkid=cc3fdb88c6d911ec91a3155de9eaf887.

achievable in the existing last-mile delivery system.[24] Another solution could be the "CitySnap" proof-of-concept vehicle, developed by Rinspeed. It shows a solution for innovative, sustainable, and efficient delivery that can be implemented at short notice. Customer orientation is the main factor here, because the customer, with his demands and needs, is the focus in all facets. People want more and more convenience and simplicity, but also sustainability in their lives. This unique delivery solution offers both.[25]

**Figure 6:** DiPPER last-mile delivery system [26]

### *Benefits of delivery robots and mobile pick-up points*

Delivery robots and mobile pick-up points offer various benefits:

- **Environmentally friendly & efficient:** Delivery robots may reduce the number of large delivery vehicles that are forced to double park, causing traffic congestion, increasing vehicle miles travelled, and thus increasing greenhouse gas emissions.
- **Delivery regardless of time, climate, or other influencing factors**: Another advantage is that the ordered goods can be picked up at a defined pick-up point within a defined time window. This enables working people in particular to pick up the goods

[24] DiPP-R AB, "NEXT GENERATION E-COMMERCE LOGISTICS SYSTEM," 2022, https://www.dipp-r.com/?msclkid=db2247f7c70211ecad01c5629e66bfad, accessed April 2022.
[25] Rinspeed AG, "Rinspeed Citysnap: "CitySnap" reduces traffic, emissions, and costs - focus on customer convenience and efficiency," 2022, https://www.rinspeed.com/de/?msclkid=1082a569c6d811ec93d73d2c88e2f753.
[26] DiPP-R AB, "NEXT GENERATION E-COMMERCE LOGISTICS SYSTEM," 2022, https://www.dipp-r.com/?msclkid=db2247f7c70211ecad01c5629e66bfad, accessed April 2022.

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early in the morning or late in the evening, irrespective of regular opening hours. Delivery robots can be in operation at any time of the day or night.

- **Moderate investment costs:** The main costs for autonomous delivery robots are hardware, electricity, and remote operators. Unlike electric vehicles, the battery is not the largest cost component for slow-moving robots. Consequently, rolling robots do not require large batteries, which lowers both hardware and electricity costs compared to traditional electric vehicles.
- **Assistance for people with mobility issues:** The introduction of delivery robots could significantly positively impact communities of people with mobility issues. These devices are a low-cost, quick way to get medication, groceries, or other items, and they have the potential to completely transform the lives of people with mobility issues.
- **Affordable delivery:** The same day, free delivery is a huge cost, requiring couriers to spend tens of billions of dollars every year. Last-mile delivery is responsible for the high delivery costs. As a result, same-day deliveries, inherently short-distance deliveries, are extremely costly. Delivery robots offer a convenient alternative to human-centered deliveries at a fraction of the cost.
- **Increased safety:** Despite some early setbacks, delivery robots may prove to be a safer alternative to traditional delivery methods. Having a robot replace a human, for example, will put fewer couriers in a precarious position where they often have to handle cash late at night. Aside from driver safety, delivery robots may also help keep pedestrians safe.

## 5 Discussion

The elaboration of the aspects of technical and economic feasibility as well as the environmental benefits for the business case of a bus fleet conversion to hydrogen buses revealed problems and opportunities in all three aspects, which should be considered accordingly for a successful fleet conversion.

The examination of the technical feasibility has shown that sufficient $H_2$ bus models are available on the market to serve numerous different operating profiles. In comparison, the supply in other market segments such as heavy-duty trucks with two $H_2$ truck manufacturers is significantly lower and illustrates that the market of vehicles with alternative drives must first grow accordingly. Due to the market development, the delivery time specifications of the manufacturers must be reviewed regularly and taken into account for the planned schedule of the fleet conversion. For the business case considered, the range spectrum of $H_2$ buses on the market is sufficient to take over the existing operating profiles of diesel buses in regional transport and to be supplied via a central fuel infrastructure, which represents the ideal case of a technology change. However, the range of the vehicles with alternative drives available on the market will continue to be a central issue in the technical feasibility of a fleet changeover for some time to come, as the ranges are still significantly lower than those of conventional diesel vehicles. This often complicates the adoption of existing operating profiles or even requires a replanning and splitting of routes with associated additional costs for additional vehicles, personnel costs and decentralized charging infrastructures, which can already make a fleet conversion financially unviable.

Longer refuelling times can further exacerbate this problem in the absence of time flexibility.

The examination of the economic feasibility in the business case shows that a fleet conversion to $H_2$ buses in the region considered is still associated with additional costs in terms of TCO. The high additional investment costs in vehicle acquisition could already be mitigated by corresponding national subsidy programs but there are still considerable additional costs for $H_2$ vehicles in terms of fuel costs and maintenance costs. However, previous studies on the cost development of $H_2$ vehicles show a uniform picture of a strong cost reduction and cost parity with diesel vehicles by the year 2030.[27,28,29] Since these studies do not take into account toll reductions, $CO_2$ taxes and subsidies for vehicle acquisition costs, a significantly earlier cost parity can be expected with appropriate public measures. In Austria, a 75% toll reduction on highways is already granted for zero-emission vehicles.[30] The $CO_2$ tax in Austria, which will come into force in July 2022, will successively lead to an increase in the price of diesel fuel to 13.5 €-cent/litre by 2025 and will continue to rise.[31] In contrast, the production prices of green hydrogen are expected to show a significant cost reduction of up to 60% by 2030 with a corresponding expansion of renewable energy sources.[32] These cost factors should be included in future cost comparisons and forecasts to create a comparison that is as close to reality as possible.

In terms of environmental benefits, hydrogen vehicles offer a large potential for emission reduction, provided that the hydrogen used is produced from renewable energy. The use of blue hydrogen as a transitional solution would be conceivable until corresponding production capacities for green hydrogen are established. The use of grey hydrogen leads to higher emission levels than conventional diesel vehicles and can therefore be rejected.

We now turn to the consideration of last mile logistics. The advantages mentioned in the upper part seem to be quite a bit ahead of current logistics standards, and there also seem to be many solutions in the field of robotics in the area of sustainability. In any case, one point to be discussed is the cost in the development and production of delivery robots. The cost of manufacturing delivery robots will initially be high, but the overall costs will reduce

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[27] Jörn Neuhausen et al., "Making zero-emission trucking a reality: Truck Study 2020: Routes to decarbonizing commercial vehicles," 2020, https://www.strategyand.pwc.com/de/en/industries/transport/green-trucking-2020/truck-study-2020.pdf, accessed November 2021.

[28] Yvonne Ruf et al., "Fuel Cells Hydrogen Trucks: Heavy-Duty's High Performance Green Solution," 2020, https://fuelcelltrucks.eu/wp-content/uploads/2021/03/roland_berger_fuel_cells_hydrogen_trucks.pdf, accessed November 2021.

[29] Deloitte, "Fueling the future of mobility: hydrogen and fuel cell solutions for heavy duty long-haul freight transportation," 2020, https://www2.deloitte.com/content/dam/Deloitte/fr/Documents/energie-et-ressources/Publications/etude-fueling-the-future-mobility-long-haul-trucks.pdf, accessed January 2022.

[30] ASFiNAG, "GO toll for trucks, buses and heavy motorhomes," ASFiNAG, 2022, https://www.asfinag.at/en/toll/go-toll/, accessed April 2022.

[31] Angela Köppl, Stefan Schleicher, and Margit Schratzenstaller, "CO2-Bepreisung in der Steuerreform 2022/2024," 2021, https://www.wifo.ac.at/jart/prj3/wifo/resources/person_dokument/person_dokument.jart?publikationsid=69168&mime_type=application/pdf, accessed July 2022.

[32] Hydrogen Council, "Path to hydrogen competitiveness: A cost perspective," 2020, https://hydrogencouncil.com/wp-content/uploads/2020/01/Path-to-Hydrogen-Competitiveness_Full-Study-1.pdf, accessed January 2022.

gradually with an increase in the number of deliveries.[33] But in comparison with electric vehicles, autonomous delivery robots are roughly seven times more efficient on a mile per kilowatt basis, and rolling robots do not require large batteries, lowering both hardware and electricity costs relative to more traditional electric vehicles.[34] Sooner or later, there will be no way around new sustainable solutions for the last mile. Overall, the 'last mile' is transforming in many ways. How quickly it succeeds will ultimately come down to two factors, which are consumer driven experience and investments in infrastructure.

The service itself will be as important as the delivery of product. The companies that win in creating a service that enables individuals to get what they want, when they need it, whether it be at the home or the office, will compete the best. With all these changes to the last mile, it is imperative for companies to look at redesigning their supply chains to better serve the consumer as well.

In both topics, Mobilab2.0 sees itself primarily in demand in its supporting and advisory function, in order to point out the best possible solutions for companies and institutions through research projects or studies, but also to point out possible difficulties in the implementation of these solutions. To fulfil this function as a supporter and enabler, MobiLab2.0, like all other Austrian Living Labs, committed to cooperate in the so-called cooperation platform KAMÖ (Cooperation and Exchange Platform Mobility Labs Austria) when submitting its applications for the new funding period, which runs until 2026. This networking at both the federal, regional, and local levels represent an essential asset for the holistic consideration and further development of freight and passenger mobility in Austria. A key factor in this context is the broad base that the Labs represent via the cooperation and exchange platform. Each Lab is closely networked with its local stakeholders and in exchange with the other Labs at the federal level. In this way, local developments and thrusts can be reflected on at a higher level and jointly developed further. In this way, frictional losses are minimized, and a common knowledge base is created and continuously developed. This contributes to faster development and better transferability to the entire mobility ecosystem. The Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation, and Technology supports this cooperation and sees it as a very effective way of acting together sustainably throughout Austria and providing the best possible support to both private and public institutions in this regard.

## 6 Conclusion and further research

In this study MobiLab2.0 was presented and the two core themes sustainable last mile logistics and the identification of sustainable fleets and the necessary infrastructure were examined in more detail to show our scientific support in these topics and to discuss problems and possibilities of implementation.

The discussion of sustainable fleet conversion on the basis of a business case for fleet conversion to $H_2$ buses has shown that a systematic consideration of the aspect's technical feasibility, economic feasibility and ecological benefits must be considered specifically for

[33] Naveen Joshi, "The use of robots for last-mile delivery," 2019, https://www.bbntimes.com/technology/the-use-of-robots-for-last-mile-delivery#:~:text=Another%20major%20issue%20faced%20in%20last-mile%20delivery%20is,during%20non-working%20hours%20when%20there%20is%20low%20traffic.
[34] S. Korus, "Autonomous Delivery Robots Could Lower the Cost of Last Mile Delivery by 20-Fold," Ark invest, 2018, https://ark-invest.com/articles/analyst-research/autonomous-delivery-robots/?msclkid=56b5d05dc78711ec8797a50039c0256c, accessed April 2022.

the respective use, continuously re-evaluated and compared with other technologies in order to find an optimal solution for the respective fleet conversion. The business case was limited to a comparison of diesel and fuel cell vehicles and should be extended accordingly to other technologies such as electric vehicles to consider and compare as many options as possible. The same procedure should also be applied to other market segments, such as heavy-duty trucks, to provide the necessary scientific support for fleet conversion. In addition to the support of companies, scientific advice to the public sector is also needed to adjust the necessary subsidies for a technology change accordingly. For this purpose, Mobilab2.0 will conduct a market analysis of the current demand for zero-emission buses in Austria.

In order to keep abreast of the latest research in the field of sustainable last mile logistics, this topic must continue to be considered and pursued at MobiLab2.0. The main tasks for the future will be to consider new innovative solutions and approaches and to integrate them in the environment of the MobiLab2.0 to test the applicability of these solutions in the urban/rural area. Advantages and disadvantages, opportunities and difficulties must be explored and compared with the use of finances, people, and infrastructure. The financial feasibility must also be reviewed and reconsidered to be able to justify the use of new technologies to funding bodies.

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