A Work Project, presented as part of the requirements for the Award of a Master's degree in Management from the Nova School of Business and Economics.

# ASSESSING THE SUSTAINABLE IMPACT OF ALTERNATIVE FORMS OF PROPULSION AND SMART MOBILITY ON ACHIEVING THE TRANSPORT-RELATED GOALS OF THE EUROPEAN GREEN DEAL:

## A THREE PILLAR SUSTAINABILITY APPROACH

PHILIP ZELLER DA COSTA E SILVA (52673)

*Sustainable impact measurement - the concept of smart mobility*

Work project carried out under the supervision of:

JOÃO CASTRO

19/06/2023

## Abstract

This study aims to present the concept of smart mobility, assessing its potential to achieve the European Green Deal transportation targets by developing an adjusted three-pillar model incorporating indicators derived from the EGD transportation goals. The results of the sustainable impact measurement reveal that the investigated concept possesses the potential to create an overall impact toward achieving the desired targets. However, the effects on the social, environmental, and economic pillars vary significantly. The research thus delivers a validated and applicable sustainability assessment framework for mobility concepts, providing valuable insights and recommendations for stakeholders and policymakers.

**Keywords**

Alternative propulsion, Automotive Industry, Autonomous Driving, Biogas, Circular Economy, Connected Vehicles, Decarbonization, Electromobility, European Green Deal, Fuel Cell, Greenhouse Gas, Hydrogen, Impact, Mobility, Shared Mobility, Smart Mobility, Sustainable Development, Sustainability, Three Pillars, Transportation

This work used infrastructure and resources funded by Fundação para a Ciência e a Tecnologia (UID/ECO/00124/2013, UID/ECO/00124/2019 and Social Sciences DataLab, Project 22209), POR Lisboa (LISBOA-01-0145-FEDER-007722 and Social Sciences DataLab, Project 22209) and POR Norte (Social Sciences DataLab, Project 22209)

# Table of Contents

**Abstract** ..... **1**

**Table of Figures** ..... **I**

**Table of Tables** ..... **II**

**List of Abbreviations** ..... **III**

**1. Introduction** ..... **2**

**2. Evaluation of Sustainable Concepts** ..... **4**

2.1. Definition of Sustainability and Sustainable Development ..... 4

2.2. Models of Sustainable Impact Measurement ..... 4

2.3. Specific Models for Mobility Concepts ..... 5

2.4. The Three Pillars of Sustainability ..... 7

2.4.1. Social ..... 7

2.4.2. Environmental ..... 7

2.4.3. Economic ..... 8

2.4.4. General Approach ..... 8

**3. European Green Deal** ..... **9**

3.1. Elements ..... 10

3.2. Relevance of Transport-related Industry ..... 11

3.2.1. Transport Modes and Goals ..... 12

3.2.2. Special Consideration of Road Transportation ..... 12

**4. European Automotive Industry** ..... **13**

4.1. Definition and Delimitation ..... 13

4.2. Current State and Trends ..... 14

**5. The European Green Deal and its Influence on the Automotive Industry** ..... **14**

5.1. Introduction to Self-developed Model ..... 14

5.2. Selected EGD Targets for Transportation and Derived Indicators ..... 15

5.2.1. Social: Accessibility/Affordability and Safety ..... 15
5.2.2. Environmental: Reduction of GHG Emissions and Circular Economy ..... 16
5.2.3. Economic: Economic Growth and Creation of Jobs ..... 17
**6. Empirical Study ..... 18**
6.1. Methodical Approach and Data Collection Process ..... 18
6.2. Selection of Experts and Implementation ..... 18
6.3. Data Analysis ..... 19
**7. Introduction to the Individual Part ..... 19**
7.1 Sustainable Impact Measurement - Smart Mobility ..... 20
1. Introduction ..... 20
2. Smart Mobility ..... 20
2.1 Components ..... 20
2.2 Validation of Sustainable Impact Model – Literature Review ..... 23
2.3 Validation of Sustainable Impact Model - Empirical Study Results ..... 27
2.4 Discussion ..... 30
**8. Conclusion ..... 34**
**9. Limitations and Future Outlook ..... 36**
**References ..... 37**
**Appendix I ..... 57**
**Appendix II ..... 58**
**Appendix III ..... 60**
Transcript Interviewee E1 ..... 60
Transcript Interviewee E2 ..... 69
Transcript Interviewee E3 ..... 79
Transcript Interviewee E4 ..... 91
Transcript Interviewee E5 ..... 101
Transcript Interviewee E6 ..... 112

Transcript Interviewee E7 ..... 123
Transcript Interviewee E8 ..... 133
Transcript Interviewee E9 ..... 143
Transcript Interviewee E10 ..... 155
Transcript Interviewee E11 ..... 171

## Table of Figures

**Figure 1**: Three Pillars of Sustainability. Taken from (Purvis, Mao, and Robinson 2019, 682) 7

**Figure 2:** Greenhouse Gas Emissions by Source Sector. Taken from (Eurostat 2022) ..... 11

**Figure 3**: Self-developed Model. Own Illustration..... 57

## Table of Tables

**Table 1**: Interviewed Experts. Own illustration ..... 57

## List of Abbreviations

| | |
|---|---|
| **AD** | Autonomous Driving |
| **BEV** | Battery Electric Vehicle |
| **CO2** | Carbon dioxide |
| **CNG** | Compressed Natural Gas |
| **CVs** | Connected Vehicles |
| **EGD** | European Green Deal |
| **EIA** | Environmental impact assessment |
| **EVs** | Electric Vehicles |
| **FCEVs** | Fuel cell electric vehicles |
| **GDP** | Gross domestic Product |
| **GHG** | Greenhouse Gas |
| **HEVs** | Hybrid electric vehicles |
| **HICEVs** | Hydrogen internal combustion engine vehicles |
| **HVs** | Hydrogen vehicles |
| **ICE** | Internal combustion engine |
| **LNG** | Liquid natural gas |
| **PHEVs** | Plug-in hybrid vehicles |
| **REEVs** | Range-extended electric vehicles |
| **RQ** | Research Question |
| **SDGs** | Sustainable Development Goals |
| **SA** | Sustainable assessment |
| **V2I** | Vehicle-to-infrastructure |
| **V2V** | Vehicle-to-vehicle |
| **UN** | United Nations |

# 1. Introduction

In November 2022, world leaders convened at the Climate Change Conference (COP27) to intensify their efforts to restrict global warming to 1.5°C, with individual countries disagreeing on many key decisions (United Nations 2022; Harvey 2022). The consequences of not consistently pursuing common objectives are described in the latest report of the IPCC (2023) which postulates that "*continued greenhouse gas emissions will lead to increasing global warming, with the best estimate of reaching 1.5°C in the near term*". Moreover, the IPCC warns that a failure to achieve the climate targets will lead to "*Widespread and rapid changes in the atmosphere, ocean, cryosphere and biosphere"* (ibid.). Therefore, policy instruments like the European Green Deal (EGD) are crucial to combat this development and achieve the 1.5°C targets, while minimizing negative climate impacts. The agreement is segmented into various areas with the overarching goal of becoming "*the first climate-neutral continent by 2050*" (European Commission 2021b). One of these segments is dedicated to transportation, which, in contrast to all other addressed sectors, increased its emissions since 1990 (World Economic Forum 2022). A recent approach by the European Union (EU) to curtail transport-related CO2 was to prohibit the sale of internal combustion engine (ICE) vehicles by 2035 (Abnett 2023). Moreover, the EU's emission reduction strategy relies heavily on digitalization to enable the implementation of smart mobility (European Commission 2020e).

Given that the EU has proposed alternative forms of propulsion and smart mobility as the main solutions to reduce transport emissions, this paper aims to analyze the potential impact of these two concepts in greater detail with respect to the EGD targets for transportation (European Commission 2020g). However, existing studies on the topic are divided and often exclusively focus on the impacts of alternative propulsion (i.a. Nuri Cihat Onat et al. 2019, 461; Mizik and Gyarmati 2022, 608; You, Kwon, and Kim 2020, 24159; Nuri C. Onat and Kucukvar 2022, 3) and/or smart mobility (i.a. Shaheen et al. 2017; Greenblatt and Shaheen 2015; Martínez-Díaz

and Soriguera 2018a; Fagnant and Kockelman 2015a) on the frequently used assessment approach of the three pillars of sustainability. A link to the EGD goals has been poorly explored so far. To address this gap, this paper develops, implements, and validates a model for measuring the sustainable impact of mobility solutions based on these three pillars. Furthermore, it seeks to combine academic knowledge and practical experience, to allow clear assumptions about the possible impacts of the concepts on the transportation goals. Consequently, the research question that emerges from the research gap can be stated as follows: "*To what extent do the concepts of alternative propulsion and smart mobility impact the three pillars of sustainability in achieving the transport-related goals of the European Green Deal?".*

The study is divided into 9 Chapters. Following the introduction, the second Chapter seeks to establish a common understanding of the relevant terms and provides an overview of existing models assessing sustainable impact. In particular, the Chapter describes the three pillars of sustainable development and their application. This is followed by a brief overview of the elements of the European Green Deal, with a specific focus on the transport sector and more specifically, road transportation. In the succeeding section, the European automotive industry is introduced, offering a comprehensive examination of its current trends and forms. After establishing a basic understanding of the topic, Chapter 5 presents the model for assessing sustainable impacts, which has been developed by the authors. This framework outlines the transport-related goals of the EGD and links them to the three pillars of sustainability by using indicators. Before applying the model, the methodical approach is described in Chapter 6. Subsequently, Chapter 7 provides the introduction to the individual part, whereby both parts follow the same structure. First, each concept is analyzed based on a further literature review and a qualitative approach followed by a discussion of the findings utilizing the self-developed framework. Building on this, a conclusion containing the answer to the research question is given, before the paper ends with the Limitations and a Future Outlook.

# 2. Evaluation of Sustainable Concepts

## *2.1. Definition of Sustainability and Sustainable Development*

The term "sustainability" can be understood from several different perspectives. Often it is considered in the context of other terms like Biological Resource Use, Energy, Society, or Economy which is why it has many different and specific definitions. This might also be the explanation why the search for a uniform definition often results in statements such as: „*The synthesis […] reveals a lack of a clear definition of sustainability "* (Smith and Sharicz 2011, 73), „*It seems clear that sustainability can mean several things […] and, […], they are far from holistic*" (Santilo 2007, 62) or "*Sustainability is an […] vague concept whose scientific definition and measurement still lack wide acceptance"* (Phillis and Andriantiatsaholiniaina 2001, 435)". The most noticeable consistent characteristic that connects the majority of the definitions is the combination with the three dimensions of sustainability: social, environmental, and economic (i.a. Rogers and Carter 2008, 360; Kuhlman and Farrington 2010, 3438; Purvis, Mao, and Robinson 2019, 1). Since the literature lacks a clear and unified definition of "sustainability", this paper uses the related term of "sustainable development". In this context, most of the literature refers to the definition provided by the United Nations (UN) in 1987 (i.a. Basiago 1995, 109; Howarth 1997, 445; Santilo 2017, 60). There, "sustainable development" is described as a *"development, which meets the needs of the present without compromising the ability of future generations to meet their own needs"* (United Nations 1987).

## *2.2. Models of Sustainable Impact Measurement*

Regarding the measurement of sustainable impact, a common approach are impact assessments as one of their main goals includes contributing to sustainable development (International Association for Impact Assessment 2009, 1). The EU conducts this process by relying on one of its first directives implemented in 1985 called the Environmental impact assessment (EIA) which is continuously updated and mainly used to measure the environmental impact of projects

(European Commission 2023d). Another form used by the EU is Sustainable impact assessments (SIA) which focus more on trade negotiations (European Commission 2023l). Most of the sustainable assessments (SA) involve a screening process including an impact analysis based on the three pillars of sustainability (i.a. Ness et al. 2007, 499; Hacking and Guthrie 2008, 74–85; OECD 2010, 4–30). In this regard Lauesen (2013, 2382) provides a helpful overview of the possible implementation approaches that exist in the field of SA, ranging from qualitative models e.g., the ecological footprint, to indexes focusing on physiological factors e.g., the well-being index. A third framework, again based on the three pillars, are the UN's 17 Sustainable Development Goals (SDGs), which summarize the progress of sustainable development and define necessary changes for achieving the goals of the 2030 Agenda (United Nations 2023) (Purvis, Mao, and Robinson 2019, 683–95). However, all the introduced models lack a precise focus on mobility solutions. Therefore, different impact assessments focusing on mobility will be described in the following.

### *2.3. Specific Models for Mobility Concepts*

The common literature provides evaluation models and approaches that specifically help to evaluate sustainable mobility concepts. Gompf, Traverso, and Hetterich (2020, 1) for example conduct a social life cycle assessment (SLCA) with a focus on mobility services and base their assessment on a comprehensive literature review, including the current state of 579 social indicators. Coppolaa and Silvestria (2020, 55) aim to measure the sustainable degree of potential mobility solutions and, in this context, apply an integrated system of mathematical models to simulate the interactions between land use and transportation (STIT-framework). Within the context of the literature research, two suitable methods for assessing mobility concepts were found, namely the ASIF-model and the SMob-Scale. The ASIF-model is used to calculate transport-related GHG emissions and is calculated by multiplying the performance of the transport mode (activity), the modal-split of passenger and freight transportation (modal

share), the energy demand by transport mode (energy intensity) and the carbon intensity per unit (carbon content of Fuels) (Schipper 2002, 14). The model suggests being extended with the three pillars, to allow a measurement of GHG emissions of the entire socio-economic system (Lopez-Ruiz et al. 2013, 14). The second approach to measure the sustainability of mobility concepts is provided by Bebber et al. (2021, 1) whose aim is the development and validation of a mobility assessment scale also known as SMob-Scale. The procedure for creating such a scale is based on defined sustainable dimensions that arise from the goals of the Sustainable development of communes and services (ISO 37120 and ISO 37122 goals), and the UN Sustainable Development Goals. Through this, the current state of urban sustainable mobility can be identified (ibid., 1).

However, almost all of these methods exhibit a high level of complexity, large amounts of data, and uneven focal areas. In addition to that, to obtain a significant overall assessment and to ensure valid comparability, those complex analyses would have to be conducted separately for all mobility concepts to be tested, which would clearly go beyond the scope of this paper. Therefore, the approaches mentioned above are intended solely to provide an overview of sustainable mobility assessment methods and can be understood as a basis for further research. Since answering the research question requires a consistent assessment model including the comparison of different mobility concepts linked to the EGD mobility targets, and since the selection of such quantitative frameworks in the literature is limited, the authors conclude to rely on the basic three-pillar approach. As already mentioned, this framework is widely used in the literature (i.a. Rogers and Carter 2008, 360; Kuhlman and Farrington 2010, 3438; Purvis, Mao, and Robinson 2019, 1) and has, therefore, the potential to serve as a foundation for evaluating and comparing various mobility concepts. The method is described in more detail in the following, as it represents the foundation of the self-developed model created by the authors in Chapter 5.1.

### *2.4. The Three Pillars of Sustainability*

According to the concept of the three sustainable pillars, sustainability can be split into three different categories: society, environment, and economy (Moldan, Janoušková, and Hák 2012, 4). As the goals of these areas frequently stay in conflict with each other, the overlap of all these three can be referred to as sustainability (Purvis, Mao, and Robinson 2019, 688).

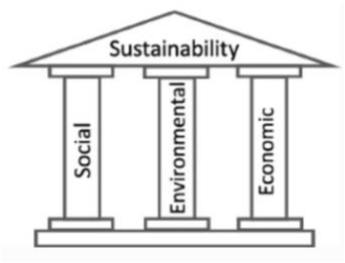


**Figure 1**: Three Pillars of Sustainability. Taken from (Purvis, Mao, and Robinson 2019, 682)

#### *2.4.1. Social*

Social sustainability can be defined as *"the extent to which social values, social identities, social relationships, and social institutions can continue into the future"* (Moldan, Janoušková, and Hák 2012, 4). It can be divided into 4 different categories: Equity (equal opportunities concerning education, housing, and healthcare but also access to clean water and healthy nutrition), Raising awareness regarding sustainability in the public and providing proper education, Participation (the more people involved in the decision-making process of policies or new regulations the more it will be accepted by society) and Social cohesion (fighting mental health diseases and crime) (Murphy 2012, 18–25). In this regard, the EU released 20 social rights principles divided into 3 areas: fair opportunities and accessibility in the workplace, working conditions, and a functional welfare system (European Commission 2023h).

#### *2.4.2. Environmental*

Environmental sustainability can be defined by stating that it *"seeks to improve human welfare by protecting the sources of raw materials used for human needs and ensuring that the sinks for human wastes are not exceeded, in order to prevent harm to humans"*(Goodland 1995, 3).

The overall goal is to maintain the ecosystem healthily through responsible production and consumption, meaning increasing the implementation of renewable resources to compensate for the consumption of resources that cannot be regenerated. It further includes that no pollutants should be exposed to the environment (Moldan, Janoušková, and Hák 2012, 6–7).

### *2.4.3. Economic*

The goal of the economic pillar of sustainability is to make sure that sustainable economic growth is both feasible and profitable. Providing equitable access to resources and benefits involves developing regulations that stimulate investments in renewable energy sources and encouraging fair trade practices in a way that contributes to an increase in the general well-being of society (Emerick 2023). Key elements of the economic pillar is an economic growth which includes economic development in an environmentally and socially sustainable manner (United Nations 1987, 7). Moreover, it includes the ability to optimize the efficient use of resources and the fair distribution of them in order to provide the same number of non-renewable resources to the next generation (Cabeza Gutés 1996, 147).

### *2.4.4. General Approach*

When applying the three pillars, there are once again different approaches that differ primarily in their level of detail in the evaluation of the sustainable impact. In the simplest form, the procedure is based on indicators defined in the literature for each pillar (i.a. Spangenberg et al. 2002, 2; Moldan, Janoušková, and Hák 2012, 1; UN 2001). According to the UN (2001, 26) "*Guidelines and Methodologies of Indicators of Sustainable Development*", it is important to comply with certain criteria when establishing indicators. Indicators should be, among others: relevant to assessing sustainable progress, understandable, clear, unambiguous, and should have the ability to be developed within the capabilities of national governments. In this regard, the UN report states that there are certain advantages in using indicators such as: help in evaluating

government objectives and their revisions, facilitating the preparation and monitoring of plans, and to better assessing sustainable policies and action performance during the implementation (ibid., 9). Examples of selected UN indicators are among others: Access (Social), Emission of Greenhouse Gases (Environmental), or Gross Domestic Product (GDP) per Capita (Economic) (ibid., 89, 124, 204). Throughout the remainder of this paper, a total of six indicators (two indicators per pillar) will be utilized. These indicators have been formulated in accordance with the mentioned UN report, the transport related EGD targets, and the automotive sector and will serve as a basis for the self-developed model, to ultimately provide a conclusive response to the overarching research question. The six distinct indicators will be expounded upon in Chapter 5.2. In the following, the EGD will be described in more detail.

## 3. European Green Deal

The EGD was announced by the European Commission President Ursula von der Leyen on December 11th, 2019, as a comprehensive plan to establish Europe as the "*first climate-neutral continent by 2050*" (European Commission 2019c). It includes important measures to be implemented and aims to achieve economic growth within the EU without further harming the environment. Another objective is to minimize the negative impacts related to climate change. The agreement consists of multiple initiatives determined for different sectors such as energy, industry, agriculture, sustainable finance, and transport, which are closely interlinked, in order to reach the overall goal of climate neutrality (Schipper 2011, 359; European Council 2022b). In the following, an initial description of the EGD elements and its funding is given. Subsequently, the significance of the transport sector including its objectives is elaborated with a specific focus on road transportation.

### *3.1. Elements*

The eight individual policies of the EGD, are briefly summarized below. "*Increasing the EU's climate ambitions for 2030 and 2050*" is represented by the goal of "*cutting net greenhouse gas emissions in the EU by at least 55% by 2030, compared to 1990 levels"* (European Commission 2019b, 4). By 2050 the amount of GHG produced and absorbed should be equal (European Council 2022b). "*Supplying clean, affordable, and secure energy*" will be facilitated by a rapid transition to a renewable energy system and should focus on improving the progress of digitization (European Commission 2019b, 6). "*Mobilising the industry for a clean and circular economy*" will be conducted by relying on innovative solutions to solve the issues of e.g., waste management (ibid., 7). "*Building and renovating in an energy and resource-efficient way*" mentions the creation of an infrastructure where resources can be pooled together to benefit from economies of scale (ibid., 9). "*A zero-pollution ambition for a toxic-free environment*" will be created by implementing the zero-pollution plan and setting clear goals for removing toxic substances from our atmosphere and products (ibid., 14). The biodiversity strategy for 2030 includes action plans to restore ecosystems and address the issues of the maritime sector that will help "*preserving and restoring ecosystems and biodiversity*" (ibid., 13). A fair, healthy, and environmentally friendly food system will be achieved by following the "*farm-to-fork strategy*" minimizing the usage of pesticides, and incentivizing the concept of organic farming (European Council 2022a; ibid., 12) . "*Accelerating the shift to sustainable and smart mobility*" plays a key role in achieving the required 90% reduction in transport related GHG emissions (ibid., 10). Smart infrastructures improve traffic management and the expansion of charging infrastructure for new technologies as well as the production of low-emission vehicles should increase (European Council 2022b). The ***"Financing the transition"*** policy is based on an investment plan which will provide a framework to incentivize a mix of public and private investment in order to achieve the required additional funding of €260 million per year to

achieve the EGD targets (European Commission 2020b). The "Just Transition" mechanism is put in place to follow the principle of "***leaving no one behind***" (European Commission 2023i). In this context, a focus will be laid on reorganizing the education and training processes by funding the re-education of the workforce and broadening the awareness of sustainable practices amongst the population (ibid.).

### *3.2. Relevance of Transport-related Industry*

A major obstacle on the way to a sustainable economic system is the transport sector, which accounts for about 25% of total EU GHG emissions (Ajanovic and Glatt 2020, 136). On the other hand, this industry contributes around 5% to the EU's GDP and employs more than 10 million people making it crucial for EU businesses and supply chains (European Commission 2020d). Figure 2 shows the development of GHG emissions in transportation as well as the development in the other sectors addressed in the EGD for the period 1990 to 2020.

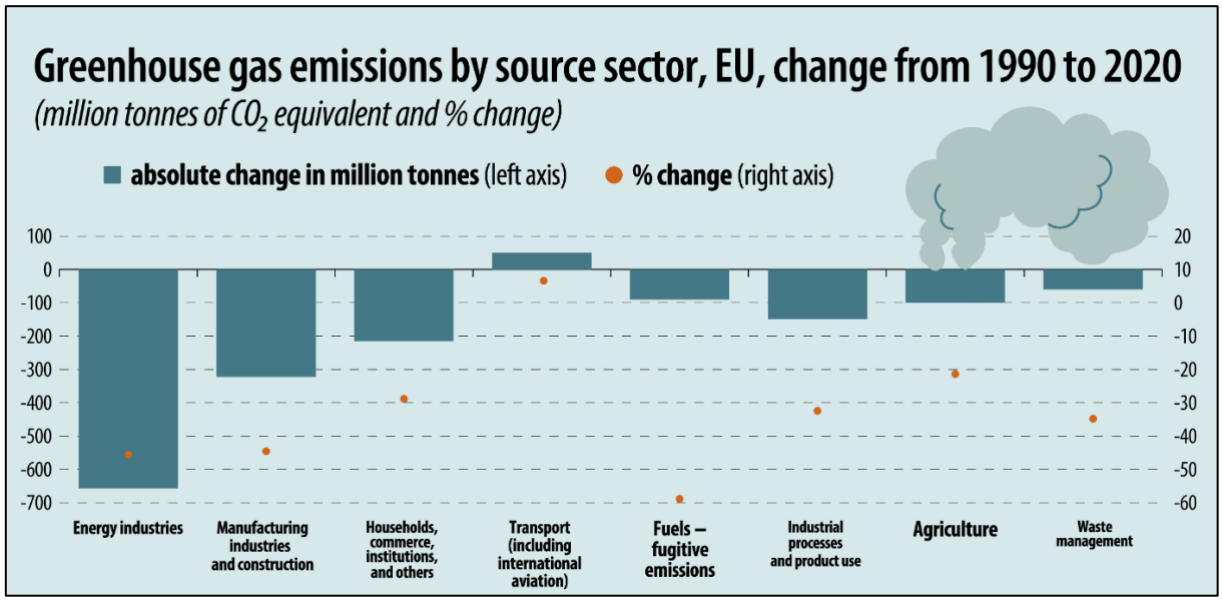


**Figure 2:** Greenhouse Gas Emissions by Source Sector. Taken from (Eurostat 2022)

The Figure illustrates that other sectors such as energy and manufacturing could reduce their emissions since the 1990s, while transport emissions have increased, which is why a shift in precisely this industry is of huge importance in order to achieve the overall EGD targets.

### *3.2.1. Transport Modes and Goals*

The European Commission has presented an action plan as part of its "Sustainable and Smart Mobility Strategy", which is intended to set the basis for a more sustainable, intelligent, safe, and accessible EU transport system in the future and whose overall goal is to achieve the under 3.1. mentioned a 90% reduction in emissions by 2050 (European Commission 2020g, 2). This plan classifies the transportation sector into **five** different modes (European Commission 2023j). This includes the aviation industry, road transport, railways, maritime transport, and inland waterways (ibid.). Each of these modes of transport plays an important role in the mobility of people and goods as well as the overall economic development of a country.

### *3.2.2. Special Consideration of Road Transportation*

By considering the five modes of transportation described in 3.2.1. and to allow a further narrowing of transportation it is necessary to determine which of the aforementioned forms has the highest CO2 emissions and therefore the greatest need for action, as achieving a climate-neutral continent by 2050 describes the overarching goal of the EGD. In the context of literature research, it becomes clear that road transport is not only the main mode of transportation that comes to mind when thinking of mobility but also the one with the highest CO2 emissions (Ritchie 2020; European Environment Agency 2021). However, measuring emissions for each mode of transportation requires information about distance, fuel, cargo load, traffic density, and occupancy rate to ensure meaningful comparability. This makes it difficult to identify the single largest emitter of CO2 (Gonçalves 2019; Sivak 2015, 3). When looking at the standard forms of mobility of people, the literature indicates that technological optimizations have indeed greatly reduced CO2 emissions per passenger mile in recent years, especially in air transport (Gonçalves 2019). As trains are increasingly electrified, this fact makes the car as a passenger transport mode the largest GHG emitter in this field (ibid.). With regard to freight transportation, recent numbers from the ITF Transport Outlook (2021) show that heavy vehicles

such as trucks account for 65% of the largest share of freight emissions here. Also in the EU freight, 76.70% of carbon dioxide emissions come from road transport and only 15.30% from maritime transport (EEA - European Commission 2022, 135). This apparently makes road transportation the largest CO2 emitter in freight and passenger transport. Due to this relevance, this paper concentrates exclusively on road-related modes of transportation. As a result, the term "road transportation" as well as the term "mobility" throughout this paper exclusively refers to the European automotive industry, which will be described in detail in the following.

# 4. European Automotive Industry

The automobile industry supports 6.1% of all employment in the EU, providing 5 million direct jobs and 8.8 million indirect jobs to Europeans (European Commission 2023a). The industry thus has a share of 7% of the European gross domestic product (GDP) and is connected to various industries that rely on automotive performance (ibid.). Due to its high emissions compared to other five modes of transport (3.2.2.), the industry will play a crucial role in the transformation process to achieve the overall EGD goal of a climate-neutral continent by 2050.

## *4.1. Definition and Delimitation*

First of all, it is important to distinguish between transportation and the automotive industry. In contrast to the transportation sector which includes different types of modes (3.2.1.), the term automotive industry can be defined as "*companies engaged in the production of motor vehicles, engines, trailers, bodywork, and motor vehicle parts and accessories*" (Olschewski, Wallentowitz, and Freialdenhoven 2009, 1). However, some sources in the literature define the term more broadly and also include companies involved in downstream activities of car manufacturing or logistics service providers (ibid.). The European Commission has its own categorization of types of vehicles that can be classified within the automotive industry, which include among others buses, trucks or Electric Vehicles (EVs) (European Commission 2023b).

### *4.2. Current State and Trends*

With regard to the current stand and trends of the industry, the literature indicates that the automotive branch is indeed already changing towards innovations and fossil-free drive systems, with many solutions being planned or already being implemented. Electric engines, Digitalization, IoT, Climate Change and new resulting policies such as the EGD agreement have already transformed the market and might lead to further disruptive developments (Moore 2022). Sales for Electric Vehicles in 2023 are expected to be 14,3 million cars, which describes a growth of 36% in contrast to the year 2022 (Irle 2022). The growth potential of the European shared mobility market is already estimated at €70 billion in 2022 and could rise to €150-200 billion by 2030 (Heineke et al. 2022). The most widespread industry trends are diverse mobility (e.g., Subscription-based Vehicle Userships and Micro-mobility), autonomous driving, electrified respectively carbon-free vehicles, and connectivity services, which, according to many sources, will shape the development of the entire industry in the next decade (i.a. Moore 2022; Gao et al. 2016; Singh 2021; J. Howarth 2021).

## 5. The European Green Deal and its Influence on the Automotive Industry

### *5.1. Introduction to Self-developed Model*

With the adoption of the EGD, concrete targets and guidelines were defined that must be implemented by the various sectors, including the automotive industry. As previously indicated, the literature review revealed that most of the existing models for assessing the sustainable impacts of mobility solutions do not connect indicators with specific targets, which makes it difficult to link those models to climate policies such as the EDG targets. Consequently, the authors have attempted to develop and apply a model in accordance with the theoretical approach of implementing the sustainable three pillars (2.4.4.). Thereby, two indicators per pillar were identified based on the EGD targets for transportation (5.2.). The two indicators were then assigned to their respective pillar to enable a better differentiation within the column

and allow a clearer analysis of the two examined concepts (7.). For a better understanding of the self-developed model, Figure 4 depicts a graphical illustration.

### *5.2. Selected EGD Targets for Transportation and Derived Indicators*

In the following, the two indicators are listed in the context of the corresponding pillar with a more detailed explanation of the associated EGD transport objective.

#### *5.2.1. Social: Accessibility/Affordability and Safety*

**1.** In the social pillar the first goal that should be achieved refers to **accessibility and affordability** defined in the EGD as *"make mobility fair and just for all*" (European Commission 2023e). This is also reflected in the European pillar of Social Rights as one of its principles is defined as "*access to essential services*", where transportation is specifically mentioned (European Commission 2023h; 2023e). The focus is laid on rural areas where the transport infrastructure should be improved, especially for older people or "*people with reduced mobility*" (ibid.). Therefore, the European Commission has conducted a study on the social responsibilities that the transition to a greener and more digital transport system should entail. There, one of the main findings again highlights the lack of access to transport systems in rural areas as a major challenge (ibid.). Moreover, the trend of suburbanization refers to people with low-paid jobs and lower education levels being forced to move from the city to rural areas where rent prices are lower increasing the urgency of the affordable accessibility to mobility concepts in rural areas even more (European Commission and Kouris 2022, 25). A lack of access in rural areas would in turn forces workers to rely on owning a private vehicle (ibid., 209).

**2.** The second goal addresses the challenge of increasing **road safety** which has been defined as the following: "*by 2050, the death toll for all modes of transport in the EU will be close to zero"* (European Commission 2020d). In this context, the EU safety framework aims to

implement a "*Safe system*" (European Commission 2019a, 2–3). By doing so, it is intended to reduce the impact of human errors by creating a corresponding infrastructure that already accounts for those. In addition, the implementation of further safety improvements is addressed, with the automation of mobility and the sharing economy being particularly highlighted as key components (ibid., 4-5). Besides, the WHO (2019, 8–16) emphasizes four areas in relation to road safety as the main challenges to be tackled: speed limit on the roads, driving under the influence of alcohol, use of safety equipment, and a functioning infrastructure.

#### *5.2.2. Environmental: Reduction of GHG Emissions and Circular Economy*

For the environmental pillar, the overarching EGD target of reducing greenhouse gas emissions by 2030 respectively 2050 serves as a foundation. With regard to the transport sector, GHG emissions must be reduced by 90 % by 2050 (European Commission 2020d).

**1.** The first indicator challenges the **reduction of GHG emissions of the current transport modes**. This will play a significant role in achieving the transport-related targets of the EGD. To meet this objective, a rapid increase in the utilization of renewable energies, the development of a correlating infrastructure, and the development of new sustainable propulsion alternatives is essential (European Commission 2020f; 2019b, 8–24). In this regard, the European Commission has defined the following milestones: "*by 2030 at least 30 million zero-emission vehicles will be in operation on European roads*" while "*100 European cities will be climate neutral*" (European Commission 2020f, 2). In addition to that, the EU aims that "*by 2050 nearly all cars, vans, buses as well as new heavy-duty vehicles will be zero-emission*" (ibid., 3).

**2.** Another certified goal of the EU is the implementation of a **circular economy** connected to the goal of "*decoupling growth from resource use*" (European Commission 2020c, 3–6). The aim relies on the idea of sustainable resource use and equalling consumption with the regeneration of materials. This refers to increasing the lifetimes of products, facilitating repair

and maintenance processes, recycling materials, and reducing the emissions of production processes (ibid., 4). In this context, especially the area of batteries and vehicle production is of particular relevance for the automobile industry (ibid., 8).

#### *5.2.3. Economic: Economic Growth and Creation of Jobs*

**1.** In the context of the economic dimension, the objective is to achieve an increase in **economic growth** while taking into account the other two pillars (United Nations 1987, 7). The EU already announced that even as a fully decarbonized continent its economy is expected to double by 2050 compared to 1990 (European Commission 2023n, 1). Furthermore, new investments in technologies and the development of new markets should lead to a growing GDP (ibid.). In this regard, one of the primary objectives is leveraging digitalization and being more resilient when facing crisis's (European Commission 2020g, 1). Additionally, the EU emphasizes investment in the transport infrastructure, with a focus on green freight transport, and seeks to strengthen the European single market (ibid., 15-16). Moreover, growth should be strengthened through economies of scale and lower costs for small and medium-sized enterprises, while the competitiveness of European companies is secured (European Commission 2023g; 2019b, 16).

**2.** A second target formulated by the EU is to **create more green job opportunities** through the transition to a more sustainable economy. In general, this will mean a great effort in re- and upskilling of around 6 million people (European Commission 2014; 2020a). Moreover, 800,000 extra workers alone in the battery industry are required to make the transformation to carbon-neutral mobility possible (European Commission 2023k, 14). In addition, the EU envisages modernizing manufacturing facilities and emphasizes an improved working environment as well as high-quality jobs that could become more attractive to women and young people

(European Commission 2023m, 13–14). Overall the industry attempts to create 1 million jobs by 2030 while also securing existing employment (European Commission 2023c; 2023m, 1).

# 6. Empirical Study

The methodical approach is based on the self-developed model (5.1.) to estimate the sustainable impact of the two chosen concepts of alternative propulsion and smart mobility. This paper aims to validate this model and answer the research question based on data that goes beyond this theoretical state of research. Therefore, a further, more specific literature review of the selected concepts combined with a qualitative approach was conducted. In this regard, experts of mobility companies as well as independent representatives of the automotive industry were interviewed to generate further knowledge and be able to better correlate the results from the literature. The subsequent discussion contrasts the literature review with the expert opinions and allows for the author's own estimation. The methodology is applied in Chapter 7.

## *6.1. Methodical Approach and Data Collection Process*

The expert interview is an integral part of the applied qualitative paradigm and well suited for this paper, as experts not only have in-depth knowledge, but can also provide practical experience at the same time (Bogner, Littig, and Menz 2014, 13). A common method for interviewing experts is the guided interview (Kühl, Strodtholz, and Taffertshofer 2009, 32). To additionally allow some space for discussion and enable digression, the semi-structured guided interview was chosen and applied in the data collection process of the paper (Adams 2015, 493). The created and applied semi-structured guidelines can be found in Appendix II.

## *6.2. Selection of Experts and Implementation*

Concerning the research question of this paper, three criteria were required from the experts in order to obtain valuable empirical findings. 1) Comprehensive understanding of sustainable mobility trends; 2) Expertise of automotive industry concepts, including alternative forms of

propulsion and smart mobility and 3) Knowledge of EGD policies and transportation goals. The list of interviewed experts can be found in Appendix I. During the implementation, the three questions derived from the three pillars of sustainability with sub-questions were asked to the experts. The interviews were recorded and transcribed, with some complex details simplified for a better understanding (Bogner, Littig, and Menz 2009, 35). The transcripts are listed in Appendix III.

### *6.3. Data Analysis*

To be able to evaluate the content of the interviews in the best possible way, the interviews were examined using a deductive system of categories. Through this technique, text components of the transcripts are addressed by different categories and thus systematically filtered out (Mayring 2022, 97). The categories represent the indicators that were determined in connection with the chosen three-pillar approach and the transport-related targets of the EGD (5.). The filtered content from the transcripts was summarized as text and processed as a result.

## 7. Introduction to the Individual Part

The following individual part involves an analysis of the selected and already mentioned mobility concept (1.) using the methodology described in Chapter 6. Philip Zeller investigates the concept of smart mobility (7.1). The individual part concludes with a discussion, in which the author tries to assess the potential sustainable impact of their respective mobility concept, based on the self-developed model. To estimate this potential impact more precisely, the analysis categorizes the impact levels into **low potential, average potential, and high potential.**

### *7.1 Sustainable Impact Measurement - Smart Mobility*

*Individual part Philip Zeller da Costa e Silva (52673)*

## *1. Introduction*

Smart mobility is a relatively broad and new concept, and therefore the literature still lacks precise and clear definitions. In the paper of Albino, Berardi, and Dangelico (2015, 11) "*Smart mobility refers to the use of Information and Communication Technology in modern transport technologies to improve urban traffic*". Vanolo (2014, 887) defines it as "*local and supra-local accessibility, availability of ICTs, modern, sustainable and safe transport systems*". The most frequently used expression in the definitions of smart mobility is the use of technology in order to provide green, efficient, and affordable mobility solutions (Faria et al. 2017a; Wolter 2012, 528; Docherty, Marsden, and Anable 2018, 118) There is a wide variety of sectors that fall under the umbrella of smart mobility (Faria et al. 2017a; Docherty, Marsden, and Anable 2018, 118). To narrow the topic down the concept was divided into three main categories: **shared mobility, autonomous driving, and connected vehicles**. In the following parts, each category will be examined by relying on literature research (2.1). Thereupon in sections 2.2 and 2.3 the self-developed model will be applied based on further literature research and the results of the interviews, respectively, followed by a discussion part (2.4), estimating the impacts on achieving the EGD targets.

## *2. Smart Mobility*

### *2.1 Components*

The first concept represents **shared mobility**. The distinction between three types of sharing possibilities can be found in the common literature: **carsharing**, **ride-sharing**, and **on-demand services** (Zhu et al. 2022a, 2–4; Machado et al. 2018a, 5–12; Santos 2018a, 2–4). For **car sharing,** two business models are currently in place. In the peer-to-peer model (C2C), in which owners of private cars can let consumers utilize their property through companies serving as

the connection platform (Santos 2018a, 2). The firm Getaround provides the largest C2C car-sharing network in Europe (Getaround 2023). The B2C model consists of two variants which are station-based, where vehicles must be brought back to a certain station, and free-floating, where cars can be rented and returned within a specific zone (Machado et al. 2018a, 7–9). The firm "Share Now," a joint venture established by two of the biggest automotive companies in Germany, Mercedes Benz and BMW, combines the car-sharing initiatives of the two companies (ShareNow 2023). **Ridesharing** involves offering space in a vehicle to those going in the same direction, with vanpooling and carpooling distinguished by the type of vehicle. A third-party platform matches offerings with the demand (Zhu et al. 2022a, 2–3; Machado et al. 2018a, 11–12). BlaBlaCar represents one of the biggest players in the ridesharing industry (BlaBlaCar 2023). **On-demand services** include ride-sourcing and ride-splitting (Machado et al. 2018a, 12–14). Ride-sourcing connects drivers and users through a platform or application offered by companies (ibid., 13). One of the companies offering this service is Uber while ensuring the customers' and drivers' safety (Uber 2023a). Ride-splitting connects people with the same destination to share a vehicle and driver (Zhu et al. 2022a, 3; Machado et al. 2018a, 14). UberPool represents ride splitting where people can share their Uber rides (Uber 2023b).

The second concept of **connected vehicles (CVs)** is based on the technology of intelligent transportation systems (Faria et al. 2017b). The predominant technology relies on the Vehicle Adhoc network (VANET) which is based on built-in sensors in the vehicles and infrastructure to exchange information with little dependency on a well-functioning internet connection (Alam, Ferreira, and Fonseca 2016, 95). In this paper, the focus will lie on Vehicle-to-vehicle (V2V) communication and Vehicle-to-infrastructure (V2I) communication. V2V communication refers to individual vehicles exchanging data which offers the possibility of traffic management, accident detection, and the field for smart parking (ibid.). V2I refers to vehicles being connected to infrastructural sensors that can be implemented e.g., into traffic

light systems or electronic fee collection tolls (Paiva et al. 2021a, 14–15; Faria et al. 2017b). Data analysis and collection are being used to lessen traffic and navigation systems lowering the time traveled (Alam, Ferreira, and Fonseca 2016, 6). An example of V2I is "*eCall*", an emergency service that immediately reaches out for help after detecting a road accident (European Commission 2023f). Applications for road safety have to include: 1.) a system of cooperative awareness messages (CAM) that disclose details about the location and condition of the vehicle and 2.) decentralized Environmental Notification Messages (DENMS) providing information about the condition of the roads (Alam, Ferreira, and Fonseca 2016, 5). Existing technologies can anticipate if another vehicle is likely to cross a red light or include warning systems detecting extreme braking behavior in the vehicle in front highly useful with little visibility. The concept of "*platooning*" ensures a safe distance between vehicles relying on automated braking systems based on V2V (Abdelkader, Elgazzar, and Khamis 2021, 13–15).

For the last concept of **autonomous driving** (AD), a distinction has to be made in terms of the degree of automation of the vehicle. The Society of Automotive Engineers has presented 6 levels that were adopted by most of the literature (SAE 2021). From level 0 to level 2 most of the activities are still conducted by the driver whereas from level 3 the car supports or conducts decision-making itself. In between levels 3 and 4, a shift to the driver is still possible while level 5 is fully autonomous (Martínez-Díaz and Soriguera 2018b, 276; Schwarting, Alonso-Mora, and Rus 2018a, 188). Autonomous vehicles in the category of 3 and 4 are soon to be introduced to the market while the complete autonomous vehicles of level 5 could take a little longer with most estimations ranging from 2025-2030 (Martínez-Díaz and Soriguera 2018b, 277–78). The whole technology is built on sensors in the car collecting data that will be processed by the hardware. In the next step, the hardware uses algorithms for the decision-making process relying on the concept of connected vehicles (S. Kato et al. 2015, 60–67). AD and CVs go together relying on one another which is referred to by the term V2X

communication (Martínez-Díaz and Soriguera 2018b, 277). Huge companies entered the AD market as Tesla, Apple, and Google are operating their first pilot projects facing some challenges. Difficulties included the enforcement of policies allowing the technologies to be tested and accidents occurring during their testing phase harming the image of the technology. However most of these accidents were caused by a third party and not the autonomous vehicle itself (Wang et al. 2020, 6). Furthermore, it is important to mention that within these projects the driver was always able to interfere with the driving (Hicks and Fitzsimmons 2019).

### *2.2 Validation of Sustainable Impact Model – Literature Review*

**Social:**

**Accessibility/Affordability:** Most of the people with reduced mobility are living concentrated in rural areas which lack access to public transport (European Commission. Directorate General for Mobility and Transport. and Steer. 2022, 43). Shared mobility can help these people operate their own private vehicles by overcoming disabilities, language barriers, or other reasons (Fleming, 2018; Shaheen et al. 2017, 52). As these services rely on the existence of an internet connection, credit cards, and smartphones this could become an obstacle (Shaheen et al. 2017, 18). Furthermore, people could be scared to make use of the service due to infection risks especially when it comes to preexisting diseases (Goralzik et al. 2022, 10). AD can increase access for people with reduced mobility by enabling people to coordinate a private car as they might not be able to otherwise (Kockelman et al. 2016, 24; Fagnant and Kockelman 2015, 170; Brown, Gonder, and Repac 2014). Another point of improving accessibility is the affordability of shared services allowing cost savings over car ownership due to the not necessary vehicle purchases and the parking expenses that are saved as well as the sharing of cost for factors such as gas, toll, etc. (Machado et al. 2018b, 3–6; Furuhata et al. 2013a, 28). With AD there is also a visible cost-saving effect due to lower repair and service costs occurring (Meyer et al. 2017, 16), and when combined with shared mobility the potential increases even more (Bösch et al.

2018, 81–83; Fagnant and Kockelman 2015, 172). CVs minimize congestion through traffic management and lead to savings in fuel costs (Janušová and Čičmancová 2016a, 18–19).

**Safety:** "*90% of accidents derive from human errors*" (Martínez-Díaz and Soriguera 2018a, 280). Therefore, huge potential lies in the concepts of AD and CVs regarding the increase of road safety (Docherty, Marsden, and Anable 2018, 115; Paiva et al. 2021b, 33). Due to the increased usage of these two concepts, a downward trend was created concerning road fatalities in developed countries but in order to observe a visible effect the connected infrastructure as well as a sufficient number of AD vehicles must be implemented (Martínez-Díaz and Soriguera 2018a, 279). Safety can be increased by AD by recorrecting mistakes but also reacting properly to mistakes made by human drivers on the road (Schwarting, Alonso-Mora, and Rus 2018b, 188; Wang et al. 2020, 10). The information exchange between vehicles will increase safety even more. Systems such as accident detection with brake systems, traffic sign alerts, or, speed and road lane management are just a few examples (Faria et al. 2017a; Paiva et al. 2021b, 25) Regarding shared mobility only the risk of not sufficiently enough trained drivers could reduce the safety (Jin et al. 2018a, 102).

**Environmental:**

**Reduction of GHG emissions:** In the study of Martin and Shaheen (2011, 1084) the reduction of the net annual GHG in North America was demonstrated as an effect of carsharing. One reason for that is the reduction of congestion (Furuhata et al. 2013b, 28). Additionally, by reducing the kilometers traveled by passengers, emissions will be further reduced (Greenblatt and Shaheen 2015a, 78). Concerning the concept of carsharing the literature agrees on a positive effect (Nijland and van Meerkerk 2017, 84; Santos 2018b, 9; Zhu et al. 2022b, 14) while there is still some doubt about the effects of ride-sourcing implying further research has to be conducted (Jin et al. 2018b, 101). Furthermore, as the usage of shared mobility increases, more

electric engines are utilized (Machado et al. 2018a, 15). The possibility of traffic management through CVs can reduce emissions by reducing congestion leading to shorter trips (Lv and Shang 2023, 2; de Souza et al. 2017). These systems optimize routes for drivers, incorporate smart parking systems, and utilize smart traffic lights to improve traffic flow, abolishing emission-intensive stop-and-go processes (Lv and Shang 2023, 8; Faria et al. 2017b; Janušová and Čičmancová 2016b, 18). Due to more efficient traffic flow from AD, fewer cars will be stuck in traffic, leading to a reduction in emissions and energy consumption (Greenblatt and Shaheen 2015a, 74; Wadud, MacKenzie, and Leiby 2016, 8). Additionally, as AD vehicles drive accordingly to the speed limit CO2 emission can be reduced (Fagnant and Kockelman 2015, 170) However, part of the researchers indicated that while emissions per mile can be lowered, the kilometers driven could be increased by the implementation of AD (ibid., 171).

**Circular economy:** Shared mobility follows the concept of the circular economy by sharing the space of the car between other people and maximizing the efficient use of the product (Sumy National Agrarian University et al. 2021, 84). Furthermore, studies indicate that shared mobility can have a decreasing effect on private car ownership (Jin et al. 2018b, 100; Greenblatt and Shaheen 2015a, 78; Nijland and van Meerkerk 2017, 84). For ride-sourcing, the literature is still hesitant as studies showed not the same decreasing effect as observed with car sharing (E. Martin, Shaheen, and Lidicker 2010, 150; Jin et al. 2018a, 100). Regarding CVs, the data obtained in the vehicle can provide very valuable insights. It can be used to recommend the most efficient use of the vehicle for the driver but also smoothen the maintenance processes with a prewarning system increasing the lifetime of the product as well as the reduction of accidents accomplished by CVs and AD (Wang et al. 2020, 10; Saidani et al. 2018, 115–16). Another approach includes the usage of AD private vehicles as taxis when not in use by their owners enabling an even higher utilization of the vehicles (World Economic Forum 2020).

**Economic:**

**Economic growth:** Due to more affordability of shared mobility users save money by not having to purchase a vehicle and therefore contribute to economic growth using the savings for other consumption fields. However, due to high capital stock, sharing companies are able to offer their services at a very cheap price, pushing the traditional taxi industry out of the market (Meng et al. 2020, 5; Machado et al. 2018b, 14; Greenblatt and Shaheen 2015b, 78). Additionally, estimations predict new sharing vehicles introduced to a city come at the cost of more than 3 vehicles (Liu, Li, and Dai 2022, 206). Due to the reduction in road accidents but also better estimations of commuting time both the concepts of CVs and AD have a positive impact on economic growth as passengers can use their time more efficiently to advance their education or work engagement (Vlachos et al. 2017, 1; Wang et al. 2020, 8–9) The benefits of full AD could amount to up to $3000-4000 for each vehicle due to more safety and less maintenance per year (Greenblatt and Shaheen 2015a, 76).

**Creation of jobs:** The job market will face a huge transformation process in the upcoming years and a high number of job losses will be observed due to the automation of processes especially in the low-skill segment. On the other hand, new job opportunities will arise with the new concepts of smart mobility emphasizing the focus in the automotive industry on the service side. The main obstacle to overcome will be the reskilling of the labor force where the demand for technical workers will increase enormously (International Labour Office, Sectoral Policies Department 2021, 30–37). Regarding the individual concepts, shared mobility offers the opportunity for vehicle owners to rent their cars and generate an additional income stream (Cohen, Adam; Shaheen, Susan 2018, 35). The reduction of vehicles will lead to fewer vehicles produced which will harm the automotive manufacturing employment. New opportunities can arise through the redesigning of the infrastructure and the maintenance of the technologies of AD and CVs (Faisal et al. 2019, 56; Crayton and Meier 2017, 250).

### *2.3 Validation of Sustainable Impact Model - Empirical Study Results*

In the following, the results of the interviews will be applied to the self-developed model.

**Social:**

**Accessibility/Affordability:** In general, investments in the infrastructure are needed to offer more accessible mobility (E1, 66-67). Rural areas are not able to establish better mobility infrastructure due to the high costs and the missing digital infrastructure to use on-demand services (E7, 6-15) (E10, 68-81). Shared mobility can solve this problem which reduces the costs by sharing the vehicles and increasing their size (E6, 45-54). The amount that can be saved by relying on shared mobility can be up to "*around €400 per month"* (E10, 83). Furthermore, shared mobility can help connect rural areas to the next mobility hub covering the so-called "*last mile*" (E6, 45-54). AD can have a huge impact on affordability just by erasing the cost for the drivers especially when it comes to larger vehicles like buses (E7, 19-25). CVs lead to a decrease in costs as the data collected can enable a demand-based offering to decrease or increase vehicle size, frequency and numbers in certain areas (E9, 20-27) (E8, 65-77). There is also a lot of potential in creating a multimodality offer (E9, 25-28). As the focus lies on rural areas the internet connection could become a problem and a critical mass must be reached for the business models to be profitable (E9, 30-37) (E10, 103-112).

**Safety:** Shared mobility leads to fewer people driving under the influence of alcohol (E3, 94-96). Furthermore, as car-sharing vehicles are on average more modern than private cars it can be assumed that they are equipped with more advanced security systems (E3, 102-104). AD as one of these technologies will be especially easy to use on motorways and country roads (E3, 80-83). Lower levels of AD e.g., remote driving (a not physically present person is maneuvering the car) are being used already (E6, 64-69). In general, it can be said the higher the level of automation the more secure the vehicle gets (E7, 70-79). While a decrease in road accident

numbers is observed in developed countries due to increasing utilization of driving assistant systems, in less developed countries numbers are still increasing (E7, 70-79). Media backlash was received in the early stages of the technology due to premature releases and accidents in the testing phase (E6, 90-94). One of the reasons is the ethical dilemmas that the software is confronted with in a decision-making situation where both outcomes inhibit negative consequences (E9, 46-57). CVs help to detect the influence of alcohol based on the steering of the vehicle and even diseases e.g., diabetes or depression. The question of access remains, concerning the data, as it can have high value to all stakeholders involved (E7, 86-94).

**Environmental:**

**Reduction of GHG emissions:** Concerning the reduction of GHG emissions, the concept of shared mobility can play a vital role as it builds on the usage of fewer resources (E10, 174-178). Furthermore "*if you don't own a private vehicle, you only drive when it's really necessary*" (E2, 165-166). Additionally, it will speed up the process in terms of electrification due to low charging costs but at the same time depends on the development of the charging infrastructure (E8, 11-19) (E2, 126-127). Regarding AD due to the controlled acceleration and braking process, a smoother and more efficient traffic flow can be ensured which produces fewer Co2 emissions and consumes less fuel (E7, 130-141) (E9, 127-128). The focus of AD lies on electric propulsion (E8, 15-16). In conducting the interviews, the statements about traffic flow management in the form of smart parking and smart traffic lights were validated as these technologies will play a vital part in reducing Co2 emissions (E7, 128-135) (E9, 126-128). More interestingly through CVs, different forms of transport modes can be combined (public transport, car sharing, bike sharing) creating a more pleasant user experience and increasing the usage of these environmentally friendly services (E10, 181-186) (E10, 197-216). In reality, cities "*want to make driving super unattractive*" (E10, 204). Therefore, the priority lies in reducing the number of vehicles replacing them with bikes or micro-mobility (E10, 197-216).

**Circular economy:** Through shared mobility private car ownership can be reduced which contributes to the idea of a circular economy (E7, 168-174). Furthermore "*independence from certain countries*" can be achieved by gaining more control over the supply chain (E7, 171). One of our interviewees highlighted the fact that in San Francisco the congestion and number of cars on the streets increased with the expansion of shared mobility offerings. In this specific case, the Covid-19 restrictions could have falsified this development due to less usage of public transport (E6, 71-79). Referring to another interview it was mentioned that shared mobility even though it will increase in the long term will always coexist with private car ownership. It was also highlighted that the applicability of shared mobility depends on the income and living situation of an individual (E10, 250-274). In the future, more public transportation companies will enter the market of shared mobility and expand their offer (E10, 250-274).

**Economic:**

**Economic growth:** There exists a "*correlation between rising traffic and rising GDP*" as the goal is to reduce traffic and emissions this "*will have a negative impact on GDP, but it will have a positive impact on sustainability"* (E2, 155-158). On the other hand, new business models will be developed as well (E5, 199), and new jobs and sectors will be generated (E2, 133-137). This could be in the form of subscription-based models or just with maintenance services (E3, 191- 198). With economic growth concerning connectivity, again the question of access to the data will play a vital role. To stay competitive, especially with American companies where data policy is very loose the topic of data sharing should be soon addressed (E9, 242-248).

**Creation of Jobs:** In order to fight the terms of "*structural unemployment*" (E7, 201) and "*useless generation*" (E6, 167) the focus has to be on upskilling the workforce preparing them for the upcoming challenges in the form of new requirements (E10, 330-339) (E6, 173-175). New jobs could also be created by consulting companies in the shift to new technologies (E3,

209-210). For AD on the first glimpse, jobs will be lost as drivers will be replaced by the software. On the other hand, it could solve the problem of a driver shortage which the industry is suffering from (E8, 162-171) (E9, 228-234). New jobs will also be created due to the technology built-in in CVs. These jobs will require a more technological background and the vehicles produced should be able to be upgraded for technological novelties (E6, 148-159).

### *2.4 Discussion*

As the results of the literature review and the interviews, have been analyzed by applying the self-derived model, the discussion part will follow the same structure summarizing and interpreting the key aspects and estimating the impact created for each pillar.

**Social Aspects – high impact:** Smart mobility can tackle the primary causes for the absence of transportation infrastructure in rural areas which are represented by high implementation costs and the lack of digital infrastructure. Through shared mobility, persons with limited mobility will be able to overcome obstacles e.g., linguistic or physical limitations, and cost savings can be achieved by saving on car purchases and parking expenses as well as the sharing of expenses of gas or toll. Obstacles include the internet connection and infection risks due to contact with other people. Wi-Fi and financial services accessibility should be improved in rural regions to address these issues. Regarding AD, the technology can help people with reduced mobility to gain more self-sufficiency increasing their range in terms of education and work access promoting inclusion in society. CVs give the chance to build a multimodal offer where sharing services and public transportation can be combined, and a more demand-based offering can be provided resulting in cost savings without relying on a well-functioning internet connection. As the rural areas are predominantly inhabited by the low-income segment the findings indicate that smart mobility will have a **moderate to high impact** on the indicators of accessibility as well as affordability.

Smart mobility has huge potential when it comes to increasing safety on the roads. As "*about 25% of all road fatalities in Europe are alcohol related*" shared mobility, as well as CVs, can have a huge impact by reducing the number of intoxicated drivers and operating with more advanced security systems (European Commission 2021a). For shared mobility, on the other hand, security risks include the familiarity of the driver with the vehicle. Efficient training of the drivers and the already existing rating system could reduce the negative effects. The security systems of the technologies of AD and CVs will increase safety due to the software correcting human mistakes which 90% of accidents are resulting from but at the same time must face decision-making in ethical dilemmas. The progress of the AD level that can be reached in the upcoming years and the implementation of the infrastructure will define the impact that can be created. The question will prevail who will have access to the data collected by CVs and where it will be stored. An online platform that all the stakeholders have access to could prevent unfair advantages. In the field of safety, especially the concepts of connectivity and AD can reduce the number of road accidents significantly. Therefore, the potential impact these technologies can have can be categorized as **high**.

**Environmental Aspects – moderate to high impact:** Shared mobility reduces Co2 emissions by reducing congestion and the kilometers driven by passengers as well as having a high electrification rate. In fact, the literature states that ride-sourcing doesn't support these positive effects on reducing GHG emissions as the reduced costs and savings for the end consumers could result in higher usage of the service. Cities' efforts in reducing the number of cars in urban areas may result in the expansion of shared mobility. AD creates a smoother traffic flow while respecting the speed limit and emitting less Co2 in total. On the other hand, researchers highlighted that in some cases kilometers driven per person can be increased with the introduction of AD. CVs as already mentioned can offer the possibility of multi-modal offers. As this service can increase the attractiveness of shared services the usage will be increased and

therefore the environmental impact can be increased. Taking all of these aspects into account the concepts will have a **high impact** on the reduction in GHG emissions.

Regarding circular economy shared mobility can maximize the usage of the vehicle by filling its capacity and reducing the number of cars in private ownership. Again, with the concept of ride-sourcing these trends have not been observed yet. During the interviews, it was highlighted that in San Francisco a study proved the opposite as car ownership rose with the number of shared mobility options but could have been deterred by the side effects of the COVID-19 restrictions. The lifetime of the product can be enhanced by the data retained from CVs to enable more efficient usage as well as the reduction of accidents by the technologies of AD and CVs. By relying on the concept of circular economy risk may be decreased as well as dependency on other nations. Supply chains won't be interrupted by political conflicts and more predictability can be obtained. The concept of smart mobility will have a **moderate impact** on the implementation of the circular economy.

**Economic Aspects – low to moderate impact:** In terms of economic growth the observed effect of cost savings due to all concepts of smart mobility provides the user with additional financial resources to spend on other fields of consumption promoting economic growth. The other observed effect of reducing accidents leads to lower costs for all stakeholders involved. In the field of shared mobility, there is an issue of unfair competition due to sharing companies creating a price war based on their high capital stock. Additionally, the reducing effect of private car ownership will have a decreasing impact on the demand for cars. This inhibits fewer workers in the manufacturers and fewer sales made by the car dealers. The effect of reduction in congestion provided by all the concepts could lead to less economic growth due to a correlation between traffic and GDP. For the technology of connectivity, it will be a question of accessibility of the data in order to stay competitive towards countries with more loose data

privacy rules. The adaption rate as well as research investments of the companies will furthermore determine their competitive status. Government incentives for the end consumers and providing the necessary infrastructure will support the companies in this transition. In the end, there can be a **low to moderate impact** created on economic growth.

In order to fight the job loss created by the automation of the process in the automotive industry the focus should be laid on the upskilling of the workforce. The required skill sets are due to a shift to a more service-oriented offering and a demand for technological knowledge of its workers. For the change towards new technologies, companies could require some guidance where in the field of consultancy new job possibilities could be built up. Through shared mobility car owners will be able to rent out their cars and become a driver themselves. The decreasing demand for vehicles will have a negative effect on the employment rate for the manufacturers as the lost profit has to be retrieved. For AD, the widespread criticism of replacing the driver and destroying jobs, it was highlighted during the interviews that in this field there is a big lack of actual people willing to do the job. Coming back to the circular economy, by basing the supply chain within the EU, jobs can be maintained and retrieved which were exported to foreign countries. In conclusion, the impact can be described as **moderate.**

This analysis demonstrated that all three concepts of smart mobility will have a remarkable impact on the three pillars of sustainable development and can make a major contribution to achieving the EGD goals. This impact varies depending on the individual pillars as for social and environmental aspects the impact is estimated to be high while for the economic pillar, the impact was estimated to be comparably low. In general, through the application of the self-developed model impact estimations were able to be established while relying heavily on the progress of the digital infrastructure enabling these technologies to fulfill their full potential.

# 8. Conclusion

This study aimed to identify the overall impact of selected mobility concepts to achieve the EGD targets for transportation and answer the posed research question: "*To what extent do the concepts of alternative propulsion and smart mobility impact the three pillars of sustainability in achieving the transport-related goals of the European Green Deal?".*

Due to the challenging task of measuring sustainable impact, a comprehensive analysis of the current state of applicable models was conducted. As the common literature only provides highly complex and unspecific frameworks, with the commonality of considering the three pillars of sustainability, the present research was built on this basis. In relevance to climate change and the resulting need to transform Europe into a sustainable, resource-efficient, and competitive economy, the objectives of the EGD were included. The further narrowed specific focus on road transport was based on the repeated failure to minimize emissions in this industry. Thus, the researchers adjusted a model that aligns with the three-pillar approach and included indicators obtained from the EGD targets for transportation in order to provide a more precise estimation of the impact the concepts might have on achieving these targets. To establish the connection to practice, a qualitative approach in the form of expert interviews was involved to better evaluate the results.

The findings of this study demonstrate an overall moderate to high sustainable influence for the social and environmental pillars, whereas the impact on the economic pillar was assessed as low to moderate. Therefore, in order to sufficiently answer the research question, it can be stated that the overarching moderate to high potential impact of alternative propulsion and smart mobility on the derived indicators implies, that the two investigated concepts are expected to play a decisive role in achieving the EGD transportation goals until 2050. However, the findings

of the literature review and the experts' opinions suggest that the investigated technologies must complement each other and that the greatest impact can be achieved by creating synergies.

These results underscore the need for automotive companies to adopt a holistic approach towards the concepts discussed and consider technologies such as connected and autonomous vehicles (CAV) combined with alternative forms of propulsion. Due to the lower impact estimations for the economic pillar, the findings suggest that action is especially required on the part of manufacturers and policymakers to secure jobs and maintain the competitiveness of the European automotive industry. This could involve retraining of employees, as well as a stronger focus and investments in software and digitalization. Recent statistics from Reuters (2023) demonstrate the significance of this issue, revealing that German BEV sales in China for instance constitute for a market share of 4.8%, representing only a quarter of the sales volume of the Chinese automaker BYD. The decline in the total market share of German car manufacturers in China, from 24.6% in 2019 to 19.1% in 2022, further underlines the urgency.

To summarize, as expected by the authors, the study results validate the impact of the concepts on the social and environmentally sustainable pillars, while also highlighting their challenging effects on the economic pillar. Furthermore, the ability to estimate the potential impact of the concepts on the achievement of the EGD transportation goals, validates the applicability of the developed sustainable impact model. Overall, the study provides important insights between existing mobility concepts and their potential impact on achieving the EDG that will shape the future European automotive industry.

## 9. Limitations and Future Outlook

Research on impact assessment models of mobility concepts addressing the achievement of climate goals remains complex and delivers mixed results. As no uniform definition of the term sustainability exists, results depend heavily on the awareness and expertise of the interviewees. This present study could therefore lead to different findings depending on the chosen experts.

Previous papers indicate that several frameworks to measuring sustainable impact exist, which makes the research results additionally dependent on the model applied. Furthermore, a different outcome through the application of a different methodological approach cannot be excluded. It would be interesting to explore the acceptance and adaptation of the individual concepts by conducting a quantitative survey in the context of further research. In addition, several sources suggest that the policy implementation process should not be ignored. Hence, future investigations should also focus on how policy can support the transformation process.

Thirdly, the technologies described have often just recently received high attention. Therefore, the existing literature is partially too imprecise to be able to derive a complete understanding of all concepts. It is uncertain to what extent the research findings described will be valid in the long term. Thus, the results should be understood as a foundation for further research.

Looking ahead, the European automotive industry faces challenges such as meeting the EGD goals and complying with stricter emissions regulations. The potential phase-out of the internal combustion engine will require rapid adaptation and new investment in new technologies. Moreover, statistics already indicate Hydrogen's future relevance especially for heavy goods transportation and emerging markets, notably China, may impact European automotive brand sales. This transformation will provide opportunities for new forms of mobility, such as air taxis while intensifying market competition. To succeed and remain competitive, manufacturers need to adapt to the changing market conditions, while prioritizing sustainable responsibility.

**References**


Abdelkader, Ghadeer, Khalid Elgazzar, and Alaa Khamis. 2021. "Connected Vehicles: Technology Review, State of the Art, Challenges and Opportunities." *Sensors* 21 (22): 7712. https://doi.org/10.3390/s21227712.

Abnett, Kate. 2023. "EU Lawmakers Approve Effective 2035 Ban on New Fossil Fuel Cars | Reuters." February 14, 2023. https://www.reuters.com/business/autos-transportation/eu-lawmakers-approve-effective-2035-ban-new-fossil-fuel-cars-2023-02-14/.

Adams, William C. 2015. "Conducting Semi-Structured Interviews." In *Handbook of Practical Program Evaluation*, edited by Kathryn E. Newcomer, Harry P. Hatry, and Joseph S. Wholey, 492–505. Hoboken, NJ, USA: John Wiley & Sons, Inc. https://doi.org/10.1002/9781119171386.ch19.

Ajanovic, Amela, and Anne Glatt. 2020. "Wirtschaftliche Und Ökologische Aspekte Der Elektromobilität." *Elektrotechnik & Informationstechnik* 137: 136–46. https://doi.org/10.1007/s00502-020-00812-x.

Alam, Muhammad, Joaquim Ferreira, and José Fonseca, eds. 2016. *Intelligent Transportation Systems*. Studies in Systems, Decision and Control. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-28183-4.

Albino, Vito, Umberto Berardi, and Rosa Maria Dangelico. 2015. "Smart Cities: Definitions, Dimensions, Performance, and Initiatives." *Journal of Urban Technology* 22 (1): 3–21. https://doi.org/10.1080/10630732.2014.942092.

Basiago, Andrew D. 1995. "Sustainable Developement." In *Methods of Defining 'Sustainability,'* 3:109–19. https://onlinelibrary.wiley.com/doi/abs/10.1002/sd.3460030302.

Bebber, Suélen, Bianca Libardi, Suane De Atayde Moschen, Marcelo Benetti Correa da Silva, Ana Cristina Fachinelli, and Matheus Lemos Nogueira. 2021. “Sustainable Mobility Scale: A Contribution for Sustainability Assessment Systems in Urban Mobility.” *Cleaner Engineering and Technology* 5 (December): 100271. https://doi.org/10.1016/j.clet.2021.100271.

BlaBlaCar. 2023. “Über Uns.” BlaBlaCar. 2023. https://blog.blablacar.de/about-us.

Bogner, Alexander, Beate Littig, and Wolfgang Menz, eds. 2009. *Interviewing Experts*. London: Palgrave Macmillan UK. https://doi.org/10.1057/9780230244276.

———. 2014. *Interviews mit Experten: Eine praxisorientierte Einführung*. Wiesbaden: Springer Fachmedien Wiesbaden. https://doi.org/10.1007/978-3-531-19416-5.

Bösch, Patrick M., Felix Becker, Henrik Becker, and Kay W. Axhausen. 2018. “Cost-Based Analysis of Autonomous Mobility Services.” *Transport Policy* 64 (May): 76–91. https://doi.org/10.1016/j.tranpol.2017.09.005.

Brown, Austin, Jeffrey Gonder, and Brittany Repac. 2014. “An Analysis of Possible Energy Impacts of Automated Vehicles.” In *Road Vehicle Automation*, edited by Gereon Meyer and Sven Beiker, 137–53. Lecture Notes in Mobility. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-05990-7_13.

Cabeza Gutés, Maite. 1996. “The Concept of Weak Sustainability.” *Ecological Economics* 17 (3): 147–56. https://doi.org/10.1016/S0921-8009(96)80003-6.

Cohen, Adam; Shaheen, Susan. 2018. “PLANNING FOR SHARED MOBILITY.” https://doi.org/10.7922/G2NV9GDD.

Coppolaa, Pierluigi, and Fulvio Silvestria. 2020. “Future Mobility and Land Use Scenarios: Impact Assessment with an Urban Case Study.” In *Transportation Research Procedia*, 42:53–63. https://www.sciencedirect.com/science/article/pii/S2352146519305733.

Crayton, Travis J., and Benjamin Mason Meier. 2017. "Autonomous Vehicles: Developing a Public Health Research Agenda to Frame the Future of Transportation Policy." *Journal of Transport & Health* 6 (September): 245–52. https://doi.org/10.1016/j.jth.2017.04.004.

Docherty, Iain, Greg Marsden, and Jillian Anable. 2018. "The Governance of Smart Mobility." *Transportation Research Part A: Policy and Practice*, Smart urban mobility, 115 (September): 114–25. https://doi.org/10.1016/j.tra.2017.09.012.

EEA - European Commission. 2022. *EU Transport in Figures - Statistical Pocketbook*. https://op.europa.eu/en/publication-detail/-/publication/f656ef8e-3e0e-11ed-92ed-01aa75ed71a1.

Emerick, Dean. 2023. "What Are the Three Pillars of Sustainability?" *ESG | The Report* (blog). 2023. https://www.esgthereport.com/what-is-esg/the-g-in-esg/what-are-the-three-pillars-of-sustainability/.

European Commission. 2014. "Employment: Commission Presents Green Employment Initiative to Support Structural Shift to Green Growth by Maximising Job Opportunities - Frequently Asked Questions."

———. 2019a. "EU Road Safety Policy Framework 2021-2030 - Next Steps towards 'Vision Zero,'" June. https://transport.ec.europa.eu/news/european-commission-welcomes-launch-global-plan-un-decade-action-road-safety-2021-2030-2021-10-28_en.

———. 2019b. "The European Green Deal - Communication from the Commission." https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52019DC0640.

———. 2019c. "The European Green Deal." Text. European Commission - European Commission. December 11, 2019. https://ec.europa.eu/commission/presscorner/detail/en/ip_19_6691.

———. 2020a. “European Skills Agenda for Sustainable Competitiveness, Social Fairness and Resilience,” January.

———. 2020b. “Financing the Green Transition.” Text. European Commission - European Commission. January 14, 2020. https://ec.europa.eu/commission/presscorner/detail/en/ip_20_17.

———. 2020c. “COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS.” March 11, 2020. https://eur-lex.europa.eu/resource.html?uri=cellar:9903b325-6388-11ea-b735-01aa75ed71a1.0017.02/DOC_1&format=PDF.

———. 2020d. “THE TRANSPORT AND MOBILITY SECTOR.” European Commission - European Commission. September 12, 2020. https://ec.europa.eu/commission/presscorner/detail/en/fs_20_2350.

———. 2020e. *COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS Sustainable and Smart Mobility Strategy – Putting European Transport on Track for the Future*. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0789.

———. 2020f. *COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS Sustainable and Smart Mobility Strategy – Putting European Transport on Track for the Future*. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0789.

———. 2020g. “Sustainable and Smart Mobility Strategy – Putting European Transport on Track for the Future.” https://eur-lex.europa.eu/resource.html?uri=cellar:5e601657-3b06-11eb-b27b-01aa75ed71a1.0001.02/DOC_1&format=PDF.

———. 2021a. “Alcohol.” January 4, 2021. https://road-safety.transport.ec.europa.eu/eu-road-safety-policy/priorities/safe-road-use/alcohol_en.

———. 2021b. “A European Green Deal.” July 14, 2021. https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en.

———. 2021c. “COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS ‘Fit for 55’: Delivering the EU’s 2030 Climate Target on the Way to Climate Neutrality.” https://www.consilium.europa.eu/en/press/press-releases/2023/04/25/fit-for-55-council-adopts-key-pieces-of-legislation-delivering-on-2030-climate-targets/.

———. 2023a. “Automotive Industry.” 2023. https://single-market-economy.ec.europa.eu/sectors/automotive-industry_en.

———. 2023b. “Automotive Industry - Vehicle Categories.” 2023. https://single-market-economy.ec.europa.eu/sectors/automotive-industry/vehicle-categories_en.

———. 2023c. “Commission Presents European Skills Agenda.” Text. European Commission - European Commission. 2023. https://ec.europa.eu/commission/presscorner/detail/en/ip_20_1196.

———. 2023d. “Environmental Impact Assessment.” 2023. https://environment.ec.europa.eu/law-and-governance/environmental-assessments/environmental-impact-assessment_en.

———. 2023e. “Mobility Strategy.” 2023. https://transport.ec.europa.eu/transport-themes/mobility-strategy_en.

———. 2023f. “Road.” 2023. https://transport.ec.europa.eu/transport-themes/intelligent-transport-systems/road_en.

———. 2023g. “Road - Mobility and Transport.” 2023. https://transport.ec.europa.eu/transport-themes/intelligent-transport-systems/road_en.

———. 2023h. “The European Pillar of Social Rights in 20 Principles.” 2023. https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/economy-works-people/jobs-growth-and-investment/european-pillar-social-rights/european-pillar-social-rights-20-principles_en.

———. 2023i. “The Just Transition Mechanism.” 2023. https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/finance-and-green-deal/just-transition-mechanism_en.

———. 2023j. “Transport Modes of EU Commission.” 2023. https://transport.ec.europa.eu/transport-modes_en.

———. 2023k. “Zero Pollution Action Plan.” January 13, 2023. https://environment.ec.europa.eu/strategy/zero-pollution-action-plan_en.

———. 2023l. “Sustainability Impact Assessments.” January 19, 2023. https://policy.trade.ec.europa.eu/analysis-and-assessment/sustainability-impact-assessments_en.

———. 2023m. “A Green Deal Industrial Plan for the Net-Zero Age.” https://commission.europa.eu/system/files/2023-02/COM_2023_62_2_EN_ACT_A%20Green%20Deal%20Industrial%20Plan%20for%20the%20Net-Zero%20Age.pdf.

———. 2023n. “Our Vision for A Clean Planet for All: Economic Transition.” March 13, 2023. https://climate.ec.europa.eu/system/files/2018-11/vision_4_economic_en.pdf.

European Commission. Directorate General for Mobility and Transport. and Steer. 2022. *Study on the Social Dimension of the Future EU Transport System Regarding Users and Passengers: Final Report.* LU: Publications Office. https://data.europa.eu/doi/10.2832/482141.

European Commission, and S Kouris. 2022. *Study on the Social Dimension of the Future EU Transport System Regarding Users and Passengers : Final Report*. Publications Office of the European Union. https://doi.org/10.2832/482141.

European Council. 2022a. “From Farm to Fork.” November 17, 2022. https://www.consilium.europa.eu/en/policies/from-farm-to-fork/.

———. 2022b. “European Green Deal.” December 6, 2022. https://www.consilium.europa.eu/en/policies/green-deal/.

European Environment Agency. 2021. “Motorised Transport: Train, Plane, Road or Boat — Which Is Greenest? — European Environment Agency.” News. March 24, 2021. https://www.eea.europa.eu/highlights/motorised-transport-train-plane-road.

Eurostat. 2022. “Greenhouse Gas Emissions Falling in Most Source Sectors.” August 23, 2022. https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20220823-1.

Fagnant, Daniel J., and Kara Kockelman. 2015. “Preparing a Nation for Autonomous Vehicles: Opportunities, Barriers and Policy Recommendations.” *Transportation Research Part A: Policy and Practice* 77 (July): 167–81. https://doi.org/10.1016/j.tra.2015.04.003.

Faisal, Asif, Tan Yigitcanlar, Md. Kamruzzaman, and Graham Currie. 2019. “Understanding Autonomous Vehicles: A Systematic Literature Review on Capability, Impact, Planning and Policy.” *Journal of Transport and Land Use* 12 (1). https://doi.org/10.5198/jtlu.2019.1405.

Faria, Ricardo, Lina Brito, Karolina Baras, and José Silva. 2017a. “Smart Mobility: A Survey.” In *2017 International Conference on Internet of Things for the Global Community (IoTGC)*, 1–8. https://doi.org/10.1109/IoTGC.2017.8008972.

———. 2017b. “Smart Mobility: A Survey.” In *2017 International Conference on Internet of Things for the Global Community (IoTGC)*, 1–8. https://doi.org/10.1109/IoTGC.2017.8008972.

Fleming, K. L. 2018. “Social Equity Considerations in the New Age of Transportation: Electric, Automated, and Shared Mobility.” 13 (1). https://planhillsborough.org/urban-design-for-shared-mobility/.

Furuhata, Masabumi, Maged Dessouky, Fernando Ordóñez, Marc-Etienne Brunet, Xiaoqing Wang, and Sven Koenig. 2013a. “Ridesharing: The State-of-the-Art and Future Directions.” *Transportation Research Part B: Methodological* 57 (November): 28–46. https://doi.org/10.1016/j.trb.2013.08.012.

———. 2013b. “Ridesharing: The State-of-the-Art and Future Directions.” *Transportation Research Part B: Methodological* 57 (November): 28–46. https://doi.org/10.1016/j.trb.2013.08.012.

Gao, Paul, Hans-Werner Kaas, Detlev Mohr, and Dominik Wee. 2016. “Disruptive Trends That Will Transform the Auto Industry | McKinsey.” January 1, 2016. https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/disruptive-trends-that-will-transform-the-auto-industry.

Getaround. 2023. “About Getaround®.” 2023. https://www.getaround.com/about?landing_page=https%3A%2F%2Fwww.getaround.com%2Fabout&lead_page=getaround.com%2Fabout.

Gompf, Katharina, Marzia Traverso, and Jörg Hetterich. 2020. “Towards Social Life Cycle Assessment of Mobility Services: Systematic Literature Review and the Way Forward.”

In *The International Journal of Life Cycle Assessment*, 25:1883–1909. https://link.springer.com/article/10.1007/s11367-020-01788-8.

Gonçalves, André. 2019. "Planes Or Cars - Which Pollutes The Most? Which Is More Sustainable?" *Youmatter* (blog). January 28, 2019. https://youmatter.world/en/plane-or-cars-which-means-of-transport-pollutes-the-most/.

Goodland, R. 1995. "The Concept of Environmental Sustainability." *Annual Review of Ecology and Systematics*, 1–24. https://doi.org/10.1146/annurev.es.26.110195.000245.

Goralzik, Anne, Alexandra König, Laura Alčiauskaitė, and Tally Hatzakis. 2022. "Shared Mobility Services: An Accessibility Assessment from the Perspective of People with Disabilities." *European Transport Research Review* 14 (1): 34. https://doi.org/10.1186/s12544-022-00559-w.

Greenblatt, Jeffery B., and Susan Shaheen. 2015a. "Automated Vehicles, On-Demand Mobility, and Environmental Impacts." *Current Sustainable/Renewable Energy Reports* 2 (3): 74–81. https://doi.org/10.1007/s40518-015-0038-5.

———. 2015b. "Automated Vehicles, On-Demand Mobility, and Environmental Impacts." *Current Sustainable/Renewable Energy Reports* 2 (3): 74–81. https://doi.org/10.1007/s40518-015-0038-5.

Hacking, Theo, and Peter Guthrie. 2008. "A Framework for Clarifying the Meaning of Triple Bottom-Line, Integrated, and Sustainability Assessment." *Environmental Impact Assessment Review* 28 (2): 73–89. https://doi.org/10.1016/j.eiar.2007.03.002.

Harvey, Fiona. 2022. "What Are the Key Outcomes of Cop27 Climate Summit?" *The Guardian*, November 20, 2022, sec. Environment. https://www.theguardian.com/environment/2022/nov/20/cop27-climate-summit-egypt-key-outcomes.

Heineke, Kersten, Benedikt Kloss, Timo Möller, and Darius Scurtu. 2022. “Snapshot of the European Car-Sharing Market.” July 5, 2022. https://www.mckinsey.com/features/mckinsey-center-for-future-mobility/mckinsey-on-urban-mobility/snapshot-of-the-european-car-sharing-market.

Hicks, Michael, and Michelle Fitzsimmons. 2019. “Self-Driving Cars: Your Complete Guide to Autonomous Vehicles.” TechRadar. June 7, 2019. https://www.techradar.com/news/self-driving-cars.

Howarth, Josh. 2021. “10 Important Auto Industry Trends (2023-2025).” Exploding Topics. March 16, 2021. https://explodingtopics.com/blog/auto-industry-trends.

Howarth, Richard B. 1997. “Defining Sustainability: An Overview.” *University of Wisconsin Press* 73(4): 445–47.

International Association for Impact Assessment. 2009. “What Is Impact Assessment?” 2009. https://www.iaia.org/news-details.php?ID=30.

International Labour Office, Sectoral Policies Department. 2021. “The Future of Work in the Automotive Industry: The Need to Invest in People’s Capabilities and Decent and Sustainable Work.” https://www.ilo.org/wcmsp5/groups/public/---ed_dialogue/---sector/documents/meetingdocument/wcms_741659.pdf.

IPCC. 2023. “AR6 Synthesis Report: Summary for Policymakers Headline Statements.” 2023. https://www.ipcc.ch/report/ar6/syr/resources/spm-headline-statements/.

Irle, Roland. 2022. “EV-Volumes - The Electric Vehicle World Sales Database.” 2022. https://www.ev-volumes.com/.

ITF Transport Outlook. 2021. “Freight Transport: Bold Action Can Decarbonise Movement of Goods.” 2021. https://www.oecd-ilibrary.org/sites/16826a30-en/1/3/5/index.html?itemId=/content/publication/16826a30-

en&_csp_=190cc6434d2fccf11e2098c12744cdb5&itemIGO=oecd&itemContentType=book.

Janušová, Lucia, and Silvia Čičmancová. 2016a. “Improving Safety of Transportation by Using Intelligent Transport Systems.” *Procedia Engineering* 134: 14–22. https://doi.org/10.1016/j.proeng.2016.01.031.

———. 2016b. “Improving Safety of Transportation by Using Intelligent Transport Systems.” *Procedia Engineering* 134: 14–22. https://doi.org/10.1016/j.proeng.2016.01.031.

Jin, Scarlett T., Hui Kong, Rachel Wu, and Daniel Z. Sui. 2018a. “Ridesourcing, the Sharing Economy, and the Future of Cities.” *Cities* 76 (June): 96–104. https://doi.org/10.1016/j.cities.2018.01.012.

———. 2018b. “Ridesourcing, the Sharing Economy, and the Future of Cities.” *Cities* 76 (June): 96–104. https://doi.org/10.1016/j.cities.2018.01.012.

Kockelman, Kara M., Lisa Loftus-Otway, Duncan Stewart, Aqshems Nichols, Wendy Wagner, Jia Li, Steve Boyles, Michael Levin, and Jun Liu. 2016. “Best Practices Guidebook for Preparing Texas for Connected and Automated Vehicles,” June. https://trid.trb.org/view/1428775.

Kühl, Stefan, Petra Strodtholz, and Andreas Taffertshofer, eds. 2009. *Handbuch Methoden der Organisationsforschung: quantitative und qualitative Methoden*. 1. Aufl. Wiesbaden: VS Verl. für Sozialwissenschaften. https://link.springer.com/book/10.1007/978-3-531-91570-8.

Kuhlman, Tom, and John Farrington. 2010. “What Is Sustainability?” *Sustainability* 2 (11): 3436–48. https://doi.org/10.3390/su2113436.

Lauesen, Linne Marie. 2013. “Sustainability Assessment Models.” In *Encyclopedia of Corporate Social Responsibility*, edited by Samuel O. Idowu, Nicholas Capaldi,

Liangrong Zu, and Ananda Das Gupta, 2378–83. Berlin, Heidelberg: Springer. https://doi.org/10.1007/978-3-642-28036-8_580.

Liu, Zhiyong, Ruimin Li, and Jingchen Dai. 2022. "Effects and Feasibility of Shared Mobility with Shared Autonomous Vehicles: An Investigation Based on Data-Driven Modeling Approach." *Transportation Research Part A: Policy and Practice* 156 (February): 206–26. https://doi.org/10.1016/j.tra.2022.01.001.

Lopez-Ruiz, Hector G., Panayotis Christidis, Hande Demirel, and Mert Kompil. 2013. "Quantifying the Effects of Sustainable Urban Mobility Plans." https://www.eltis.org/sites/default/files/trainingmaterials/quantifying_the_effects_of_sustainable_urban_mobility_plans.pdf.

Lv, Zhihan, and Wenlong Shang. 2023. "Impacts of Intelligent Transportation Systems on Energy Conservation and Emission Reduction of Transport Systems: A Comprehensive Review." *Green Technologies and Sustainability* 1 (1): 100002. https://doi.org/10.1016/j.grets.2022.100002.

Machado, Cláudia A. Soares, Nicolas Patrick Marie De Salles Hue, Fernando Tobal Berssaneti, and José Alberto Quintanilha. 2018a. "An Overview of Shared Mobility." *Sustainability* 10 (12): 4342. https://doi.org/10.3390/su10124342.

———. 2018b. "An Overview of Shared Mobility." *Sustainability* 10 (12): 4342. https://doi.org/10.3390/su10124342.

Martin, Elliot, Susan A. Shaheen, and Jeffrey Lidicker. 2010. "Impact of Carsharing on Household Vehicle Holdings: Results from North American Shared-Use Vehicle Survey." *Transportation Research Record: Journal of the Transportation Research Board* 2143 (1): 150–58. https://doi.org/10.3141/2143-19.

Martin, Elliot W., and Susan A. Shaheen. 2011. “Greenhouse Gas Emission Impacts of Carsharing in North America.” *IEEE Transactions on Intelligent Transportation Systems* 12 (4): 1074–86. https://doi.org/10.1109/TITS.2011.2158539.

Martínez-Díaz, Margarita, and Francesc Soriguera. 2018a. “Autonomous Vehicles: Theoretical and Practical Challenges.” *Transportation Research Procedia*, XIII Conference on Transport Engineering, CIT2018, 33 (January): 275–82. https://doi.org/10.1016/j.trpro.2018.10.103.

———. 2018b. “Autonomous Vehicles: Theoretical and Practical Challenges.” *Transportation Research Procedia*, XIII Conference on Transport Engineering, CIT2018, 33 (January): 275–82. https://doi.org/10.1016/j.trpro.2018.10.103.

Mayring, Philipp. 2022. *Qualitative Inhaltsanalyse: Grundlagen und Techniken*. 13., Überarbeitete Auflage. Weinheim Basel: Beltz. https://link.springer.com/chapter/10.1007/978-3-658-21308-4_42.

Meng, Tian, Songyi Cai, You Qu, Evelyn Ng, Barney Tan, and Bo Zhu. 2020. “The Dark Side of Ridesharing in China: A Case Study of Qiangsheng Taxi.” Edited by Tingsong Wang. *Discrete Dynamics in Nature and Society* 2020 (December): 1–9. https://doi.org/10.1155/2020/8816314.

Meyer, Jonas, Henrik Becker, Patrick M. Bösch, and Kay W. Axhausen. 2017. “Autonomous Vehicles: The next Jump in Accessibilities?” *Research in Transportation Economics* 62 (June): 80–91. https://doi.org/10.1016/j.retrec.2017.03.005.

Mizik, Tamás, and Gábor Gyarmati. 2022. “Three Pillars of Advanced Biofuels’ Sustainability.” *Fuels* 3 (4): 607–26. https://doi.org/10.3390/fuels3040037.

Moldan, Bedřich, Svatava Janoušková, and Tomáš Hák. 2012. “How to Understand and Measure Environmental Sustainability: Indicators and Targets.” *Ecological Indicators*,

Indicators of environmental sustainability: From concept to applications, 17 (June): 4–13. https://doi.org/10.1016/j.ecolind.2011.04.033.

Moore, Sarah. 2022. “The Current State of the Global Automotive Manufacturing Market.” AZoM.Com. November 24, 2022. https://www.azom.com/article.aspx?ArticleID=22236.

Murphy, Kevin. 2012. “The Social Pillar of Sustainable Development: A Literature Review and Framework for Policy Analysis.” *Sustainability: Science, Practice and Policy* 8 (1): 15–29. https://doi.org/10.1080/15487733.2012.11908081.

Ness, Barry, Evelin Urbel-Piirsalu, Stefan Anderberg, and Lennart Olsson. 2007. “Categorising Tools for Sustainability Assessment.” *Ecological Economics* 60 (3): 498–508. https://doi.org/10.1016/j.ecolecon.2006.07.023.

Nijland, Hans, and Jordy van Meerkerk. 2017. “Mobility and Environmental Impacts of Car Sharing in the Netherlands.” *Environmental Innovation and Societal Transitions* 23 (June): 84–91. https://doi.org/10.1016/j.eist.2017.02.001.

OECD. 2010. “Guidance on Sustainability Impact Assessment.” Text. July 5, 2010. https://www.oecd-ilibrary.org/environment/guidance-on-sustainability-impact-assessment_9789264086913-en.

Olschewski, Ingo, Henning Wallentowitz, and Arndt Freialdenhoven. 2009. “Grundlagen Der Automobilindustrie.” In *Strategien in Der Automobilindustrie*. https://link.springer.com/book/10.1007/978-3-8348-9311-6.

Onat, Nuri C., and Murat Kucukvar. 2022. “A Systematic Review on Sustainability Assessment of Electric Vehicles: Knowledge Gaps and Future Perspectives.” *Environmental Impact Assessment Review* 97 (November): 106867. https://doi.org/10.1016/j.eiar.2022.106867.

Onat, Nuri Cihat, Murat Kucukvar, Nour N.M. Aboushaqrah, and Rateb Jabbar. 2019. "How Sustainable Is Electric Mobility? A Comprehensive Sustainability Assessment Approach for the Case of Qatar." *Applied Energy* 250 (September): 461–77. https://doi.org/10.1016/j.apenergy.2019.05.076.

Paiva, Sara, Mohd Abdul Ahad, Gautami Tripathi, Noushaba Feroz, and Gabriella Casalino. 2021a. "Enabling Technologies for Urban Smart Mobility: Recent Trends, Opportunities and Challenges." *Sensors* 21 (6): 2143. https://doi.org/10.3390/s21062143.

———. 2021b. "Enabling Technologies for Urban Smart Mobility: Recent Trends, Opportunities and Challenges." *Sensors* 21 (6): 2143. https://doi.org/10.3390/s21062143.

Phillis, Yannis A, and Luc A Andriantiatsaholiniaina. 2001. "Sustainability: An Ill-Defined Concept and Its Assessment Using Fuzzy Logic." *Ecological Economics* 37 (3): 435–56. https://doi.org/10.1016/S0921-8009(00)00290-1.

Purvis, Ben, Yong Mao, and Darren Robinson. 2019. "Three Pillars of Sustainability: In Search of Conceptual Origins." *Sustainability Science* 14 (3): 681–95. https://doi.org/10.1007/s11625-018-0627-5.

Reuters. 2023. "Analysis: German Automakers Fight to Defend Their Turf from Chinese Rivals." *Reuters*, April 20, 2023, sec. Autos & Transportation. https://www.reuters.com/business/autos-transportation/german-automakers-fight-defend-their-turf-chinese-rivals-2023-04-19/.

Ritchie, Hannah. 2020. "Cars, Planes, Trains: Where Do CO2 Emissions from Transport Come From?" Our World in Data. 2020. https://ourworldindata.org/co2-emissions-from-transport.

Rogers, Dale, and Craig Carter. 2008. “A Framework of Sustainable Supply Chain Management: Moving Toward New Theory.” In *International Journal of Physical Distribution & Logistics Management 38(5)*. Vol. 38(5). https://www.researchgate.net/publication/230771054_A_Framework_of_Sustainable_Supply_Chain_Management_Moving_Toward_New_Theory.

S. Kato, E. Takeuchi, Y. Ishiguro, Y. Ninomiya, K. Takeda, and T. Hamada. 2015. “An Open Approach to Autonomous Vehicles.” *IEEE Micro* 35 (6): 60–68. https://doi.org/10.1109/MM.2015.133.

SAE. 2021. “Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles.” April 30, 2021. https://www.sae.org/standards/content/j3016_202104/.

Saidani, Michael, Bernard Yannou, Yann Leroy, and François Cluzel. 2018. “Heavy Vehicles on the Road towards the Circular Economy: Analysis and Comparison with the Automotive Industry.” *Resources, Conservation and Recycling* 135 (August): 108–22. https://doi.org/10.1016/j.resconrec.2017.06.017.

Santilo, David. 2007. “Reclaiming the Definition of Sustainability.” In *Environmental Science and Pollution Research - International*, 14:60–66. https://link.springer.com/article/10.1065/espr2007.01.375#author-information.

Santos, Georgina. 2018a. “Sustainability and Shared Mobility Models.” *Sustainability* 10 (9): 3194. https://doi.org/10.3390/su10093194.

———. 2018b. “Sustainability and Shared Mobility Models.” *Sustainability* 10 (9): 3194. https://doi.org/10.3390/su10093194.

Schipper, Lee. 2002. “Sustainable Urban Transport in the 21st Century: A New Agenda.” *Transportation Research Record: Journal of the Transportation Research Board* 1792 (1): 12–19. https://doi.org/10.3141/1792-02.

———. 2011. “Automobile Use, Fuel Economy and CO2 Emissions in Industrialized Countries: Encouraging Trends through 2008?” *Transport Policy* 2: 358–72.

Schwarting, Wilko, Javier Alonso-Mora, and Daniela Rus. 2018a. “Planning and Decision-Making for Autonomous Vehicles.” *Annual Review of Control, Robotics, and Autonomous Systems* 1 (1): 187–210. https://doi.org/10.1146/annurev-control-060117-105157.

———. 2018b. “Planning and Decision-Making for Autonomous Vehicles.” *Annual Review of Control, Robotics, and Autonomous Systems* 1 (1): 187–210. https://doi.org/10.1146/annurev-control-060117-105157.

Shaheen, Susan, Corwin Bell, Adam Cohen, Balaji Yelchuru, and Inc. Booz Allen Hamilton. 2017. “Travel Behavior: Shared Mobility and Transportation Equity.” PL-18-007. https://rosap.ntl.bts.gov/view/dot/63186.

ShareNow. 2023. “History | SHARE NOW Car-Sharing.” 2023. https://www.share-now.com/de/en/history/.

Singh, Sarwant. 2021. “Top 10 Global Automotive Trends, 2021.” Forbes. January 27, 2021. https://www.forbes.com/sites/sarwantsingh/2021/01/27/top-10-global-automotive-trends-2021/.

Sivak, Michael. 2015. “ENERGY INTENSITIES OF FLYING AND DRIVING.” University of Michigan - Transportation Research Institute. 2015. https://deepblue.lib.umich.edu/bitstream/handle/2027.42/111894/103194.pdf.

Smith, Peter A.C., and Carol Sharicz. 2011. “The Shift Needed for Sustainability.” Edited by Peter A.C. Smith. *The Learning Organization* 18 (1): 73–86. https://doi.org/10.1108/09696471111096019.

Souza, Allan M de, Celso ARL Brennand, Roberto S Yokoyama, Erick A Donato, Edmundo RM Madeira, and Leandro A Villas. 2017. “Traffic Management Systems: A

Classification, Review, Challenges, and Future Perspectives." *International Journal of Distributed Sensor Networks* 13 (4). https://doi.org/10.1177/1550147716683612.

Spangenberg, J, Deller Deller, Stefanie Pfahl, and Frank Herzog. 2002. "Towards Indicators for Institutional Sustainability: Lessons from an Analysis of Agenda 21." *Ecological Indicators* 2 (1–2): 61–77. https://doi.org/10.1016/S1470-160X(02)00050-X.

Sumy National Agrarian University, H. Kondratiiev 160, 40021 Sumy, Ukraine, Tetiana Shevchenko, Roman Vavrek, Yuriy Danko, Sumy National Agrarian University; H. Kondratiiev 160, 40021 Sumy, Ukraine, Olena Gubanova, et al. 2021. "Clarifying a Circularity Phenomenon in a Circular Economy under the Notion of Potential." *Problemy Ekorozwoju* 16 (1): 79–89. https://doi.org/10.35784/pe.2021.1.09.

Uber. 2023a. "About Us." Uber. 2023. https://www.uber.com/us/en/about/.

———. 2023b. "Uber Pool Is Now UberX Share." Uber. 2023. https://www.uber.com/au/en/ride/uberpool/.

UN. 2001. "INDICATORS OF SUSTAINABLE DEVELOPMENT: GUIDELINES AND METHODOLOGIES," 315.

United Nations. 1987. "1987: Brundtland Report." https://www.are.admin.ch/are/en/home/media/publications/sustainable-development/brundtland-report.html.

———. 2022. "COP27: Delivering for People and the Planet." United Nations. United Nations. September 20, 2022. https://www.un.org/en/climatechange/cop27.

United Nations, United Nations. 2023. "THE 17 GOALS | Sustainable Development." 2023. https://sdgs.un.org/goals.

Vanolo, Alberto. 2014. "Smartmentality: The Smart City as Disciplinary Strategy." *Urban Studies* 51 (5): 883–98. https://doi.org/10.1177/0042098013494427.

Vlachos, Evangelos, Aris S. Lalos, Kostas Berberidis, and Christos Tselios. 2017. "Autonomous Driving in 5G: Mitigating Interference in OFDM-Based Vehicular Communications." In *2017 IEEE 22nd International Workshop on Computer Aided Modeling and Design of Communication Links and Networks (CAMAD)*, 1–6. Lund, Sweden: IEEE. https://doi.org/10.1109/CAMAD.2017.8031619.

Wadud, Zia, Don MacKenzie, and Paul Leiby. 2016. "Help or Hindrance? The Travel, Energy and Carbon Impacts of Highly Automated Vehicles." *Transportation Research Part A: Policy and Practice* 86 (April): 1–18. https://doi.org/10.1016/j.tra.2015.12.001.

Wang, Jun, Li Zhang, Yanjun Huang, Jian Zhao, and Francesco Bella. 2020. "Safety of Autonomous Vehicles." *Journal of Advanced Transportation* 2020 (September): 1–13. https://doi.org/10.1155/2020/8867757.

WHO. 2019. "Global Status Report on Road Safety 2018: Summary." August 24, 2019. https://www.who.int/publications/i/item/WHO-NMH-NVI-18.20.

Wolter, Stefan. 2012. "Smart Mobility- Intelligente Vernetzung der Verkehrsangebote in Großstädten." In *Zukünftige Entwicklungen in der Mobilität: Betriebswirtschaftliche und technische Aspekte*, edited by Heike Proff, Jörg Schönharting, Dieter Schramm, and Jürgen Ziegler, 527–48. Wiesbaden: Gabler Verlag. https://doi.org/10.1007/978-3-8349-7117-3_42.

World Economic Forum. 2020. "How the Circular Economy Could Change How Cars Are Made." World Economic Forum. December 17, 2020. https://www.weforum.org/agenda/2020/12/how-the-circular-economy-could-forever-change-how-cars-are-made/.

———. 2022. "The European Union Has Cut Greenhouse Gas Emissions in Every Sector - except This One." World Economic Forum. September 29, 2022. https://www.weforum.org/agenda/2022/09/eu-greenhouse-gas-emissions-transport/.

You, Chanhee, Hweeung Kwon, and Jiyong Kim. 2020. “Economic, Environmental, and Social Impacts of the Hydrogen Supply System Combining Wind Power and Natural Gas.” *International Journal of Hydrogen Energy* 45 (46): 24159–73. https://doi.org/10.1016/j.ijhydene.2020.06.095.

Zhu, Jiangtao, Ningke Xie, Zeen Cai, Wei Tang, and Xiqun (Michael) Chen. 2022a. “A Comprehensive Review of Shared Mobility for Sustainable Transportation Systems.” *International Journal of Sustainable Transportation*, March, 1–25. https://doi.org/10.1080/15568318.2022.2054390.

———. 2022b. “A Comprehensive Review of Shared Mobility for Sustainable Transportation Systems.” *International Journal of Sustainable Transportation*, March, 1–25. https://doi.org/10.1080/15568318.2022.2054390.

# Appendix I

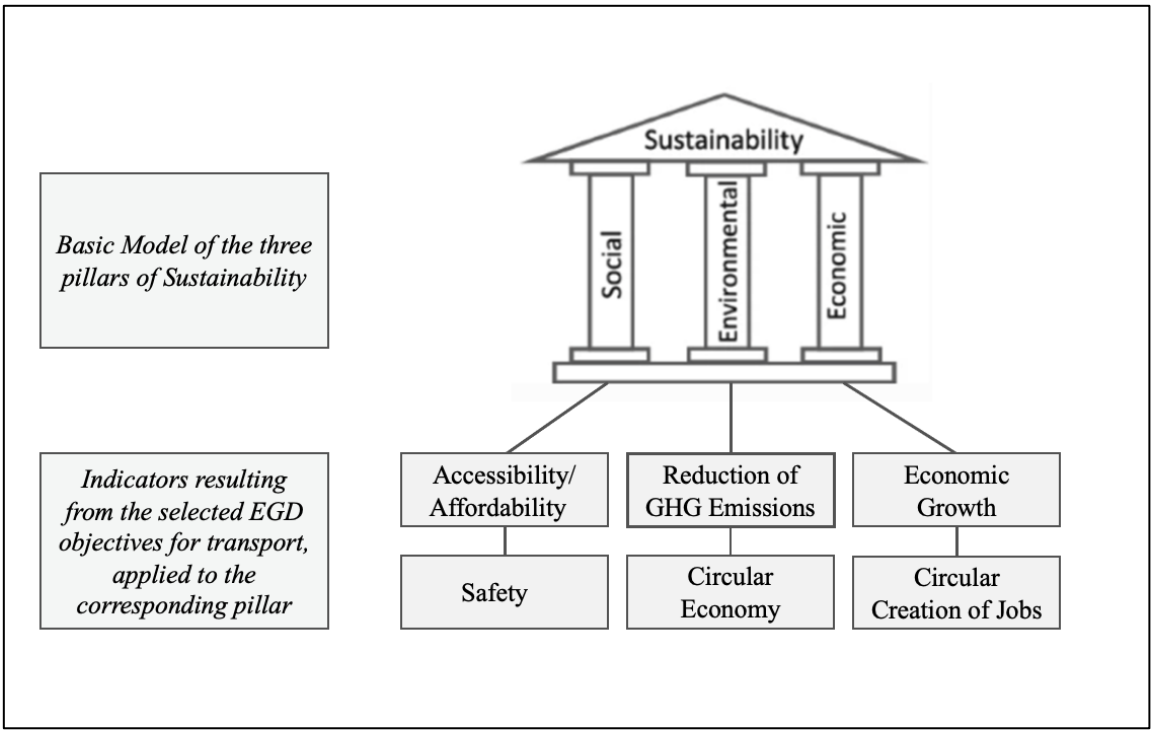


**Figure 3**: Self-developed Model. Own Illustration

| | ***Name*** | ***Role*** | ***Area of Expertise*** | ***Company/Institution*** |
|---|---|---|---|---|
| ***E1*** | Zakariaa El Hourch | Portfolio Leader | E-Mobility | Capgemini Engineering |
| ***E2*** | Tatiana Samsonova | Public Policy Manager - Sustainability | Shared Mobility | Bolt |
| ***E3*** | Leon Bordt | Consultant | Future Mobility | Future Mobility Solutions GmbH |
| ***E4*** | Frank Hofmann | Consultant | Biogas | German Biogas Association |
| ***E5*** | Simon Schmiedel | Head of Sales Control | E-Mobility | Mercedes-Benz AG |
| ***E6*** | Maya Zuckerman | Advisor | Mobilty/Circular Economy | Global New Mobility Coalition |
| ***E7*** | Andreas Herrmann | Professor & Director | Automotive Industry | University of St. Gallen - Institute for Mobility |
| ***E8*** | Till Bunsen | Policy Analyst | Transport & Energy | International Transport Forum (ITF) |
| ***E9*** | Konstantin Zech | Regulatory Advisor on Climate Action | Hydrogen and Fuels | German Association of the Automotive Industry (VDA) |
| ***E10*** | Henning Richarz | Senior Consultant | Future Mobility | UnternehmerTUM (Digital Mobility Hub) |
| ***E11*** | Manuel Rotärmel | Expert for hydrogen and synthetic fuels | Hydrogen and Fuels | DENA - German Energy Agency |

**Table 1**: Interviewed Experts. Own illustration

## Appendix II

## Semi-structured guided interview - guidelines and Introduction

The European Green Deal is an agreement between the EU countries to achieve a climate-neutral continent by 2050. Based on our literature research and expert statements, the overall research question (RQ) in the following should be answered.

***RQ**: What is the sustainable impact of the two concepts Smart mobility and alternative propulsion on the three pillars in order to reach the transport-related target of the European Green Deal until 2050?*

→ In this regard, **two** promising **sustainable mobility concepts** could be identified:

- **Smart Mobility** is composed of the concept of **shared mobility** encompassing ridesharing in the form of carpooling, car sharing with prominent examples like Uber and Bolt, **autonomous driving**, and **connectivity**, which allows for intelligent transportation systems such as electronic tolls and accident detection.

- **Alternative form of propulsion**, such as **electric mobility** (EVs) or **hydrogen** propulsion, whereby the latter can be particularly interesting for long distances traffic. In addition, **liquid natural gas** or **Biogas** propulsion which is a renewable climate-neutral fuel but still in the process of improvement in terms of efficiency and range.

→ We will use the **three pillars of sustainability** - *social, environmental, and economic* – with **two** selected indicators each, to better assess the sustainable impact of these two concepts!

## Structure

### 1. Introduction:

1. Short introduction of the topic
2. Privacy issues
3. Recording of the interview

**General Question:**

- Professional/scientific career

## 2. Main Questions:

1. **Social Pillar:** Accessibility (*to rural areas*) / Affordability & Safety

    a. Regarding the two concepts: Do you think that these concepts could make mobility more **accessible**/**affordable** for society (*Especially in rural areas*)?

    b. Regarding the two concepts: Do you think these concepts will make mobility **safer** for society (e.g., *less accidents*)?

2. **Environmental Pillar:** Reduction of GHG & Circular economy

    a. Regarding the two concepts: Do you think that these concepts promote a **decarbonized**/**emission-free** mobility?

    b. Regarding the two concepts: Do you think these concepts can contribute to the implementation of a **circular economy** in the automotive industry?

3. **Economic Pillar:** Economic growth & Creation of Jobs

    a. Regarding the two concepts: Do you believe that these two concepts can generate **economic growth**?

    b. Regarding the two concepts: Do you think that these two concepts can create more **green jobs**?

## Appendix III

***Transcript Interviewee E1***

***--- Start of recording ---***

**Lennard** [00:00:06] As I said, thank you again for your time, and good that you have already familiarized yourself with the guide. Then we can begin directly. When looking at these two concepts, the first one is Smart Mobility which includes also Shared Mobility and Second the concept of alternative propulsion which includes electric mobility, hydrogen and gas, for example. And the question is now, which of those concepts might have the highest impact on sustainability as possible.

**E1** [00:00:23] So when we talk about sustainability in general, we can't just recommend one concept for a specific situation. We are certainly not just focused on one on one. Therefore, it is important for me that we also look at public transport because it is the key to the future of mobility. And we also need to promote all kinds of non-suitable propulsion systems. Why won't it just be the electric vehicle? Because one technology will not be the key, but the coexistence of all these technologies with strong public transport can be the key to have a sustainable future.

**Lennard** [00:01:42] But do you agree that the most important trends at the moment in the automotive industry are smart mobility and electrification of vehicles or hydrogen cars? Or do we see any other trends?

**E1** [00:01:57] It is not only the mobility concept that we need to work on, but also the carbon footprint of the vehicle itself, because even the greens are on the verge of an enormous carbon

footprint. So, if we only analyze the end use of a sustainable mobility future, it is a smartphone. With the clean energy. That's fine. But if we want to have that business, we have to go through the evolution of every alternative, whether it's a car, a train or a bicycle, and try to minimize the carbon footprint of those vehicles in their life cycle. And here we will not only have to talk about mobility or EVs, but we will also have to talk about e.g., the energy industry and how they manage to produce green hydrogen and make it less polluting as possible.

**Lennard** [00:03:54] Yes, all right. A very interesting insight. Now we try to explore the three pillars of sustainability, namely social, environmental, and economic. And my next question is about the solutions. So, we have identified two indicators per pillar, for the first pillar the accessibility and safety of the new mobility concepts. Which of the two concepts we have talked about do you think offers more safety and accessibility for society? Can you give an opinion on this?

**E1** [00:04:33] Oh, I'm going to ask quick question for your project. Are you working on the sustainable mobility as an end user? So, using single mobility devices in the cities of sustainable mobility as a perimeter, or do you want to take the complete value chain into perspective.

**Lennard** [00:04:57] Yes. Both. The first and most important is the mobility in the city. So, in urban areas. This is the first question yet. But also, it's important to consider the complete value chain. So, do you think that the concept can make mobility safer and accessible?

**E1** [00:05:42] So accessibility. What do you mean by accessible?

**Lennard** [00:05:47] So could each of us now, to a certain extent, make use of lets say electromobility or shared mobility through our smartphone? Or is this only possible in urban areas because rural regions do not yet have an adequate charging infrastructure and high density is not worth it due to lack of regular demand?

**E1** [00:06:09] When we talk about accessibility, everyone will imagine how to make smart mobility accessible for people with disabilities. But the moment you give me your definition, it's more about digital inclusion. And the concept of smart mobility also includes the concept of accessibility. And that is an important pillar. The second pillar is safety. Yes, that is clear. We want to have more security for people. With new technologies, new risks have emerged that we need to address, and we need to make sure that our communities are safer, more sustainable, greener, and better connected. So those are the most important issues. And then there's affordability. You can come up with the best concept in the world, but we need to make green mobility means affordable! So I'm talking about train tickets here. I'm talking about a plane ticket. I am talking about a price for affordable mobility. They have to be affordable. At the moment, electric vehicles are still quite expensive, but that will change. But we also need the infrastructure, vehicles, and rails to make them accessible, which is not yet the case in many countries. We need to prepare the city for the conditions with the right infrastructure. And we need to make sure that the vehicles that Uber offers are environmentally friendly and accessible. Currently, electric cars are not affordable. But the technology is already there. Uber is more affordable, but often does not have a fleet of alternative fuel vehicles. Right now, we have technology that may not make our mobility carbon-free, but at least more sustainable. But to make it green, we need to offer a mode of transport that is affordable for everyone. And that requires an area-wide infrastructure cure as well as an affordable price, and that is only possible

if we look at the entire supply chain, not just the end product. this applies not only to cars, but also to public transport.

**Lennard** [00:09:47] Just come back to the affordability. So do you see a change? This, for example, electric vehicles are getting cheaper in the future and therefore are more affordable.

**E1** [00:10:02] So affordability. One way is to reduce the cost of industrialization, innovation. But when we talked about perspectives, I talked about infrastructure, which costs millions. We need money that we can invest in infrastructure. And finally, we need to be able to prepare our environment for electric cars. There are subsidies from the government. But if you want to get people to go beyond 2025, I don't know if you can. we have to make the cars cheaper and subsidies from the government. So that you don't just reach the elite, but so that everybody has access. we can't protect the environment without the right infrastructure. So, the infrastructure and the environment need the most investment and funding is the first step to a transition in the mobility sector.

**Lennard** [00:12:08] Then I would like to move on to the next question, which is environmental. And when we think about the circular economy and decarbonization. Do you think that smart mobility or electrification can have an impact on the circular economy or on decarbonization? What is your opinion on these two points?

**E1** [00:12:39] When we talk about decarbonization, we have to talk about the first point. Is the supply chain sustainable? What is the carbon footprint of this product and how can I see the extent? We must find a solution, use clean energy and clean material to build strength, and then we have to offset what we can't reduce. So it's either reduce or balance but there is lots of

greenwashing. If you are talking about recycling when you mention the circular economy, it is similar here. In principle the techniques and methods to recover batterie materials are there. But it is expensive and the profit you get from the recycled materials does not usually cover the effort that has to be invested. So companies must have that mindset of really wanting to change something and often they don't. Of course, you also need to have the required financial resources. But there are a lot of companies that are greenwashing, and that's just to communicate it. Minerals are being extracted from Africa, from all over the world, in conditions that are neither sustainable nor humane. We need to think about how we can make the means more accessible and humane for the workers to improve this industry. Because this industry will be part of the new mobility. We have a lot of batteries, and a battery group needs a lot of minerals. That has to be taken into account. Also, we have to stop creating environmental protection just for communication and stop all this greenwashing that is going on. We are still in the process of leaving fossil fuels. That's going to take years. We have to find measures that do the best job of reducing the carbon footprint. But for me, we are talking about zero carbon or net zero. To call electric vehicles, hydrogen vehicles and green gas in their current form net zero is simply greenwashing.

**Lennard** [00:15:51] Do you think there is a chance that electric cars can be completely carbon neutral in the future?

**E1** [00:16:14] Renewable energies are not always a given. We only have the sun eight hours a day, the wind not at all times of the year. We need a source of energy that is permanently available. For me, nuclear energy is a good alternative because it is a clean energy. For me, nuclear, nitrogen and natural gas are good alternatives, at least if we want to displace coal, and they do it. I will come to green hydrogen later. If we manage to break the barriers and further

increase the energy efficiency of batteries and rely more on solar energy or wind energy or develop another neutral fuel through research, then we can manage to make electromobility almost climate-neutral. But it will still take decades for batteries to be produced in a climate-neutral way and for the entire supply chain to no longer produce emissions. At the moment, we simply have to be pragmatic and do what we can with the budget available to us, because everything has its price. We want the energy to be economically viable and the investments to be worthwhile. It has to be ecologically sustainable, but also economically sustainable. Currently we give a lot of money to councils for greenwashing. So we give financial support to companies to achieve their sustainability goals or to reduce their carbon footprint, but there is just less transparency.

**Lennard** [00:19:09] In the last minute, you already talked about the economy. I read that, for example, an estimation of 6 million jobs will be lost due to the changeover to electric mobility or hydrogen. Large companies will have to change, which in turn can affect the gross domestic product. Do you think that the transformation process can also have a positive impact?

**E1** [00:19:31] That is not correct. Electrification will bring more jobs, but there will also be a shift in jobs. Yes, it's true, maybe jobs will be lost in the short term, but the jobs of electro-chemical batteries will be created, then the charging infrastructure, then the research for better efficiency of drive forms. Then there is the whole topic of shared mobility, where many companies are developing new business models. Jobs are being created. And we have millions working on the infrastructure right now. So for me, the economy is changing, because today's jobs won't exist tomorrow, and that's a good thing. The whole issue of AI also comes to mind where a lot of research is being done and jobs are being created. The states just have to take the necessary steps to adapt this kind of work to the needs of people in the future and to cut jobs

that are not up to date because new jobs will be created. For me, that is the key. But speaking of jobs, I guess some countries in Europe are a few years behind the Chinese in terms of alternativ jobs and electric mobility. So they will lose markets. But not because of the technology but because of the way they are lagging behind countries. This is not only the case for China, but also for India and even Africa, where many jobs will be created in this area.

**Lennard** [00:21:10] And regarding smart mobility, I mean, if every one of us is using shared mobility like Bolt or Uber, we don't need own cars anymore. So then the manufacturing jobs would be redundant.

**E1** [00:21:22] I am not saying that mobility coexists with special mobility. So not everyone can have access to shared mobility. So that can be a solution for big cities. We're just saying, okay, it's just more connected services, services that you can book through your smartphone. But we are talking about the same ecosystem that people need.

**Lennard** [00:22:05] And while we are on the last pillar, how do you think this will affect the countries' GDP? So, do you think that GDP will increase as a result of this change or not?

**E1** [00:22:17] It absolutely depends on the country! If you talk about countries like Morocco, all our foreign exchange is designed on energy. If we can produce our own energy, clean energy, we will win. But some other countries like Saudi Arabia export fossil fuels. So that will have a negative impact. It will be the same with some countries in Europe. The question is where will the energy come from? Will you produce your own electricity, or will you buy it from abroad? If you find an answer to this question, you will have your answer whether the country you are

looking at has a positive or negative impact in GDP. What is the current cost of your energy and what could be the cost of clean energy?

This is why I always talk about economically viable solutions. Not every solution is a good economic solution. Even if it is good from an environmental point of view. From an economic point of view, it can be a disaster, and then we should not pursue that solution.

**Lennard** [00:23:59] And for example, electric mobility. Can this be something which increases the GDP?

**E1** [00:24:08] I can speak for Morocco, for example, it will bring investment in infrastructure, it will bring investment in electric cars. It will bring more jobs for infrastructure. So, for me, it is a pillar that will create jobs and boost the economy. When I talk about another country, I am not an expert. I have done some studies on other countries in Africa and the results are positive because they already have clean energy. They spend money on infrastructure, and they have a lot of social services, as we call them. But we think it is difficult for them to invest in infrastructure. Also, they often don't know how to dispose of waste appropriately. That is still very expensive at the moment, and it affects the economy. But Germany, for example, also has a big job to do. Their energy is one of the dirtiest. So, they depend on importing their energy needs. If you manage to find alternatives to produce the energy in Germany, that will have a positive effect on GDP because less money would flow to Russia, for example. That should give incentives.

**Lennard** [00:26:29] I guess that's it. Do you have any questions? Or anything else to say or to ask?

**E1** [00:26:37] No. I wish you good luck with your thesis. And if you ever have something to publish, send me a copy.

**Lennard** [00:26:50] Yes, I think that will be the order. We'll try to get some more experts and then see where it all goes. And when the piece is finished. We'll be happy to send you a copy. Last question do you need an NDA to share confidential things and do you want to remain anonymous in our work?

**E1** [00:28:27] These are only general topics that I also publish. So, these are my opinions. So, no problem at all.

**Lennard** [00:28:41] I would like to thank you so much for your time and I will keep you updated with our possibilities.

**E1** [00:28:50] Let's stay connected and best of luck.

**Lennard** [00:28:52] Thank you very much.

**E1** [00:28:53] Bye bye.

**Lennard** [00:28:53] Thank you. Bye bye.

***Transcript Interviewee E2***

***--- Start of recording ---***

**Lennard** [00:00:00] Okay, the recording is on. Could you please introduce yourself and your profession briefly at the beginning?

**E2** [00:00:13] I work in many business areas that we have, including ride hailing, car sharing, food delivery. I also work on micro-mobility and for example our life cycle analyses. So these are environmental, technological, technical things. On the other hand, I also work a lot on policy discussions with cities and on research projects on the role of visibility of driving in cities and how we can make sure that cities implement certain levers that allow us to act and provide evidence and proof to say: yes, maybe it's the case that ride-hailing doesn't necessarily reduce kilometers driven - But if you allow that threshold to be crossed, ride-hailing will start to replace car trips, and so on, and so on. So it's also about the political side of things. So again, my role is in some ways twofold. One is more technical and is about the environmental aspects of the company and the different business units. The other is more responsible for the political discussions at European level, but also at national and local level.

**Lennard** [00:01:55] All right. Then just direct jump into that. So, we, split our, our interview into the three pillars of sustainability, which are the social, environmental and the economical and trying to evaluate the sustainability of some mobility concept in these pillars. And we indicated some, indicators for example safety and accessibility and, and so on because by doing this we can better analyze the data in the end. So the first question would be if you think about the two concept we talked about so smart mobility and alternative forms of propulsion. Do you

think this can make the automotive industry more accessible in terms of that also rural areas can participate in mobility?

**E2** [00:03:01] First of all, I'm not necessarily sure that the concept of smart mobility makes that much sense, because I'm not sure that ride-hailing is that smart. And another point I wanted to make is about LNG and that it may not be the most sustainable gas. I don't know if you've seen the Transport Environment report, but the report compares LNG trucks to diesel trucks and shows that the consumption is 10% higher. So that is just a side note.

Now, when it comes to the extent to which these two concepts can improve the accessibility of cities and rural areas, I don't think it can be done in the short term because, for example, electrification comes at a cost to cities and users and it will be a long process before, for example, an electric vehicle is more affordable than a conventional vehicle. I think it's the same trend with shared mobility, that it will be a valuable and convenient alternative to owning a car. It has to be cheap. It has to be able to be used everywhere. It has to be convenient to use. And to achieve that, there has to be a process that leads from the current situation to a broader acceptance of shared mobility, and that takes time. Firstly, I don't think we can say that we can completely eliminate private car use to maintain a similar level of accessibility. There still has to be some level of personal car use because otherwise people won't be able to get where they need to go. So I think the idea behind all these measures is to find a balance and slowly shift trips that can be made with electric vehicles or shared mobility to these modes. Does that make sense?

**Lennard** [00:05:38] Yes, that makes absolute sense. We also found that out and regarding the liquid natural gas, I read in the literature that not only it is not sustainable, but it is just an alternative proposal according to the European directives. So let's see.

**E2** [00:06:00] But I think that's kind of the way it is with all these things. There needs to be a bit more research to understand what and why. Because sometimes I think that what happens at the European level can easily be overhauled. And to change these directives is a damn long process that takes years. For this reason, there might be some policies that make sense now, but might not make sense in the future.

**Lennard** [00:06:37] All right. Staying in the social pillar. So what do you think about these two concepts and the safety issues? Do you think, for example, that with vehicle-to-vehicle communication, do you think this can make the mobility itself safer?

**E2** [00:06:56] I have no evidence to support this. But my gut feeling is that what we already see in shared mobility, for example, car sharing, is simply regulated by safety. So there are speed limits. There are certain rules that you have to follow. We have commissioned a study together with the Estonian University that shows that car sharing is much safer compared to using your own car. I think this also applies to other forms of shared mobility, including ride-hailing. It depends on the context and the kind of safety we are talking about. But when it comes to road safety, it means that this form of ride sharing is considered safer than using a private car simply because of the feeling of responsibility for another person. I also think that the alternative forms of propulsion that you talked about are safer because these often have modern technology built in such as early road danger detection and through this the potential that human errors can be reduced. But from the perspective of road safety and reducing accidents, I think shared mobility will certainly be a step towards the goals of Vision Zero.

**Lennard** [00:08:07] And smart mobility, because this could be a vehicle-to-vehicle communication?

**E2** [00:08:19] This I don't think I have enough knowledge to talk about autonomous driving and connectivity and how that might play out. I know that automation, for example, has been around for quite a while, but the question that hasn't been answered yet is how to make sure that the same level of safety is maintained. There are many open questions in that field. But to be honest, I have never been involved with automated driving and connectivity, so I don't have that knowledge.

**Lennard** [00:08:58] Totally fine. All right, then let's go to the climate pillar, which is probably the most important part because the European guidelines are there to protect the environment. So what do you think? For example, electric vehicles, can they contribute to making better use of the Circular Economy in the transport sector? Many users still don't know how to recycle the batteries.

**E2** [00:09:26] Well, I think there has to be an inevitable shift to less harmful modes of transport. That is true. And at European level, there is already a regulation for the recycling of batteries that will come into force. It is about making sure that batteries can be recycled and that they are easier to recycle. But also that they must contain components that are easy to recycle. For example, not too much energy must be used to extract the different materials for the cells, etc., etc. So this is already happening through European legislation, and this is something that needs to happen now. And yes, it is difficult. It is difficult to recycle batteries. But if we put that in relation to what happens with cars and how much they emit compared to electric vehicles. We need to understand that. We need to include the whole life cycle in the analysis, because we

can't just talk about what happens to batteries and that electric vehicles are bad, because electric vehicles are still cars, they are still based on compliance, and they are one of the solutions to reduce overall emissions when transporting anything anywhere. And the circular economy, the issue of recycling of materials and batteries in particular, I think that there are gradually more and more innovative solutions to extend the life of batteries and to recycle them without polluting the environment too much.

**Lennard** [00:11:21] Okay. And then the most important thing, I guess, is the reduction of CO2, of, you know, equalization. So what do you think is the most impactful concept in regard of CO2 emissions?

**E2** [00:11:41] I don't think there is a one-size-fits-all solution to solve this problem. To be honest, I think it is more a combination of different measures. I think the most important thing that cities should strive for is to reduce unnecessary vehicle kilometers, to shift journeys with one's own vehicle to public transport, or shared mobility, or even better shared, electrified mobility. I think it's more a question of awareness. How does this transport system work now and what kind of trips, be it short trips or longer trips, can be shifted to alternative modes of transport and give people the opportunity to choose them? Because these alternatives have to be convenient. Think about why people have their own cars. Well, you just sit down and drive to where you want to go, and that's easy. But when cities start making the car more expensive and less convenient, more space is kept free for other modes of transport, so you don't have access to cities. Then you think: okay, maybe it's actually easier for me to use a ride-share or car-share and then take public transport in the city. So I think it's a combination of different things. I personally think that electrification should not be the only focus. I think electrification is just a kind of support measure. And I think that especially in European cities, given the

structure of the urban environment, there is a lot of untapped potential to shift many trips made by private car to less harmful modes of transport through various softer measures.

**Lennard** [00:13:57] Maybe we can come back to the topic. You, as an employee of a car sharing company. Do you have the numbers? How much CO2 can be reduced if everyone would use car-sharing and things like that?

**E2** [00:14:19] Not really, not yet. But we intend to. I guarantee that we will commission a research project to find out what those numbers might be in different cities. This is, you know, a threshold. For example, if a certain number of users switch from private cars to ride-hailing, a combination of private cars and car sharing, how will that affect congestion or the environment? I think there was already a study done by UCG, I think it's called Benefits of Shared Mobility or something like that. I can make it available to you.

**Lennard** [00:15:01] That would be nice. And the Bolt cars, they are not only electric right?

**E2** [00:15:09] At the moment we have a mix for car sharing. We have a kind of bridge. As far as I know, we have car sharing and ride hailing, with our own vehicles. And those can be shared by different users. We have some electric vehicles in Estonia. We have a certain percentage of electrified vehicles. I can't tell you for sure what the percentage is. And we have petrol vehicles. We have a strategy to fully electrify our fleet. I think the car sharing industry is just a reflection of what's happening in the automotive industry. So we depend on how fast the cities introduce the charging infrastructure, but also on the manufacturers of electric vehicles, and also the price of the vehicle compared to the private cars is interesting for us.

**Lennard** [00:16:14] Thank you, then let's move on to the last pillar, the economic pillar. I read a study where the European Union says that shifting sustainable mobility concepts will eliminate about 6 million jobs in the future. So, do you think that all these business models, like for example, Bolt, um, also creates jobs, so that 6 million jobs that are probably going away will be compensated?

**E2** [00:17:07] No, I don't think I have any figures to prove that up. But my gut feeling is that if we look at the pace of adoption of new business models, there will be more drivers and there will be more people hiring those drivers. And in general, when it comes to alternative mobility or shared mobility, we have more e-scooters, we have warehousing, more operations staff, other supply chains for other manufacturing parts etc., etc. I think this will create a balance. I honestly don't know if this will fully compensate, but I know that companies like Bolt or Uber or Lyft will create jobs. I'm not sure we can call them green jobs, but they are creating jobs. Of course, there is a lot of controversy about how the workers or drivers are treated. But I think that's also one of the points of the study that we want to commission to understand how much money we bring into cities by, on the one hand, enabling people to travel, but also enabling them to earn money by ride-hailing and driving around.

**Lennard** [00:18:35] Okay. And why you say it's not only green jobs?

**E2** [00:18:41] I'm not quite sure what you mean by green jobs?

**Lennard** [00:18:46] I mean jobs like Bolt is creating, where employees are trying to make the industry more environmentally friendly with new business models.

**E2** [00:18:54] Well, yeah, I don't I honestly don't think that drivers actually think about that.

**Lennard** [00:18:58] True.

**E2** [00:18:59] We can pretend that they do.

**Lennard** [00:19:02] Okay. And then you already mentioned the city. So, do you think like the overall GDP of cities or countries can be increased through greener mobility?

**E2** [00:19:14] Well, I don't think we should talk about GDP in this context, because when we talk about sustainability and generally about a green economy or whatever, GDP is not the best indicator to measure progress. But there is a correlation between rising traffic and rising GDP. That is true. And what we want to do is reduce traffic and reduce vehicle kilometers, reduce trips, reduce employment in passenger transport, and that will have a negative impact on GDP, but it will have a positive impact on sustainability. By the way, this is something that distinguishes us from the alternative drives, because there the manufacturers probably want to sell the same amount of vehicles. If not even more! So, I think services like us are more in the context of improving wellbeing. And there are some ways that countries are trying to measure that. I think New Zealand can be an example. I think the more people switch from private vehicles to shared vehicles, the more it will have an impact on the reduction, because there are already studies that show that the number of vehicle owners is decreasing. Because when you own a private vehicle, you tend to drive more than you should or than is necessary. On the other hand, if you don't own a private vehicle, you only drive when it's really necessary. Otherwise, you use public transport or the bicycle or whatever. There is a certain discrepancy between

economic goals, which are in a way measured by GDP, and sustainability factors, which are more about improving well-being. Does that make sense?

**Lennard** [00:21:58] That makes sense. I'm right there with you, there is a study of the European Union that uses GDP as an indicator. And if you think of Germany, for example, we have Volkswagen, Mercedes-Benz. All these companies contribute to the German GDP. So if these companies have less turnover because there are other business models, then these companies might become redundant and I think that was the reason why GDP is used as an indicator.

**E2** [00:22:36] I mean, the idea that there will still be cars in the future, I understand. And to the extent that they are involved in the German economy, that that's quite important, makes sense. And I think that this is one of these discussions where you feel that the lobby of the car manufacturers is too strong, and the arguments revolve too much around these economic arguments. Because we are starting to forget that there is climate change and that we have problems that we have to deal with, so a compromise has to be made. And I think it is up to the national governments to support this relocation, that the labor market is stable in the future and ensures that the same number of jobs are maintained and that there is no impact on the general well-being of the population. It is not about concrete numbers. No. I think one should also analyze to what extent modern mobility can facilitate people's access to different opportunities. There are already studies that show that our micro mobility companies have brought X amount of money to the city because they have improved access or not. So, there is also this aspect of how much mobility contributes to the economy and to cities.

**Lennard** [00:24:07] Okay. And so overall, do you think that modern mobility contributes to economic growth?

**E2** [00:24:16] Yes, I think at the end of the day that is the case. And it's about two things, and again they are two different things, one is job creation, and by that, I mean both of your concepts that contribute to that, and the second thing is that people can move around the cities more easily without owning a car, which is more about shared mobility, but that goes hand in hand with alternative propulsion. There are a lot of people who can't afford to own a car, and I think that in the future, when shared mobility becomes cheaper, it will also allow people from lower classes to get to different places by cheaper means and to use more available alternatives.

**Lennard** [00:24:53] Thank you so much for your time and for your opinion

***Transcript Interviewee E3***

***--- Start of recording ---***

**Lennard** [00:00:00] The recording's on. Maybe at the very beginning you could say two or three words about yourself, what you do, where you come from and briefly introduce yourself and your profession.

**E3** [00:00:15] Yes, with pleasure. Hello, my name is Leon Bordt. I'm originally from Berlin. After graduating from high school, I did a commercial apprenticeship at Mercedes and then studied automotive economics for my bachelor's degree. In my Bachelor's thesis, I also dealt with plug-in hybrid vehicles in order to be able to make a future prognosis for the year 2030, and I also dealt more intensively with all forms of drive in the passenger car sector in general. And in my Master's degree I studied automotive environmental management, where I developed an electric vehicle webinar for private customers in my Master's thesis, also in the passenger car sector, to educate a little bit about certain prejudices and to reduce them if necessary. And now I work as a consultant for the company Future Mobility Solutions GmbH in the area of mobility and transportation. We actually develop and advise on new mobility concepts, especially for cities and municipalities. When companies want to become more sustainable, we come into play in order to be able to provide solutions to transportation problems and concerns.

**Lennard** [00:01:39] Great, that sounds interesting. You come from Berlin? That's very likeable. Me too. Where are you from?

**E3** [00:01:47] Yes Steglitz, Zehlendorf, the neighbourhood.

**Lennard** [00:02:11] Funny, very funny. It's a small world. Then you know your way around the automotive industry. Alright, lets jump in directly. Especially when you look at our two concepts and the three forms of drive I mentioned. What would you say is the most promising concept for the future? Electromobility, hydrogen? Or do you think that biogas also has potential?

**E3** [00:02:41] I am of the opinion that the topic of electromobility is justifiably focussed on because, at the end of the day, the efficiency is simply the highest. I had also compared this once. Even if electric vehicles are not yet powered 100% by green electricity, the efficiency is simply the highest and, depending on how you calculate, it is definitely over 40% higher than with combustion vehicles. The problem with biogas or all the others, or natural gas, is that it has simply not been focused on in recent years. Natural gas in particular could have been focused on more strongly, as its efficiency is simply much higher than that of a normal combustion vehicle. But because the focus is now so strongly on electromobility, it is difficult to make up for lost ground. And yes, on the subject of hydrogen vehicles: I think if you inform yourself a bit, it quickly becomes clear that it will be more difficult in the passenger car sector, because the efficiency is still too low. We also have very, very complex manufacturing processes in this technology.

**Lennard** [00:04:12] Interesting.

**E3** [00:04:13] Where it gets interesting is everything that goes in the direction of commercial vehicles, trucks and heavy goods traffic. We will simply reach our limits with electromobility because of the weight of heavy vehicles, which is why I would rather go for electric drive in

the passenger car sector, and hydrogen vehicles in everything that goes in the direction of transporter commercial vehicles.

**Lennard** [00:04:34] Okay, very cool. That's a good assessment. I would refer directly to the three pillars and start with the Social Piller. There we chose the indicators accessibility, especially in non-urban areas, and safety. What would you say about electric mobility, for example, in regard to accessibility? Does it only make sense in urban areas? I have read that in rural areas the charging infrastructure is often lacking. Which makes access to the technology more difficult.

**E3** [00:05:11] I think that especially in rural areas, the concept of electric mobility is important. They have the possibility to charge at home and install a photovoltaic system at home and this is the decisive factor that if you have a charging possibility at home and possibly your own home, where I can install a photovoltaic system, I simply have huge advantages and that simply makes the whole topic of electric vehicles much more interesting in rural areas. Also, for the reason that the population in rural areas simply does not want to live without their own cars. Shared mobility is a bit more difficult, or car sharing there. Rather, because people are simply used to having their own cars. As I said, it is a huge incentive to have your own charging station with self-produced electricity, then the charging infrastructure is no longer an issue.

**Lennard** [00:06:13] Okay. And in terms of affordable, an electric vehicle can also be expensive or is currently still very expensive. Especially if you also have to buy your own charging station. Does that also exclude people? What would you say?

**E3** [00:06:25] Yes, depending on the vehicle, model and equipment, the initial purchase price is €5,000 - 7,000 more expensive than a comparable combustion engine, even when the eco-rebate is taken into account. So the first hurdle is definitely a bit bigger. But what you have to bear in mind, and many people do not, is that you will of course save certain costs over the lifetime of the car. The maintenance costs are lower because fewer wearing parts, and there are also tax advantages and insurance advantages. So after eight years, for example, it is cheaper than with a combustion vehicle. So, if you look at the ownership over the entire life cycle, you save about two and a half to €3,000, depending on the car. I also made a comparison with the Skoda Maniac and the comparable combustion engine from Skoda, and also for an Opel Corsa, a small car and the comparable electric version. And after eight years of operation, there was a cost advantage for the electric vehicle. If you make it clear to people that the maintenance costs are simply so much cheaper, and that in the end the electric vehicles is therefore also cheaper, then I don't think it's such a big factor.

**Lennard** [00:07:45] Okay, that's an interesting assessment. What about the issue of safety? Do you think that the selected concepts will make road traffic safer through, for example, V to V communication? I was told that the electric car in particular has a longer braking distance because it is heavier. What do you think about that?

**E3** [00:08:11] So in principle, definitely. Especially in rural areas, where you don't have as much traffic as in the city and also don't have all these exceptional situations that are often talked about. I think the topic of autonomous driving will also play a greater role there. For example, on motorways or country roads, where there are simply fewer factors, assistance systems and autonomous driving will become easier. And all these safety systems are

developing further and further. This means that vehicles per se are becoming safer and safer and brake on their own when an obstacle comes along.

Regarding longer braking distance. So far, I haven't dealt with this as much. Depending on the situation, you would have to weigh it up, of course, because maybe the vehicles also have larger braking systems installed? On the subject of whether or not a vehicle catches fire more often, you can look at the statistics published by Tesla in America. And it turns out that an electric vehicle burns much less than a combustion car. So from that point of view, I wouldn't see the safety aspect of electric cars as critical, but rather as an advantage. The whole issue of autonomous driving with connectivity, as you mentioned, which is really a factor in reducing traffic accidents, is also important. Yes, what I would like to say on this point is also the topic of shared mobility, which should be promoted in rural areas, where public transport is usually not so well developed. The better this issue of car sharing is developed, the less people are motivated to drive under the influence of alcohol after they have been to a party. Since public transport is also not sufficiently developed and I now live in a village, I often don't have the opportunity to get home at all.

**Lennard** [00:10:33] So with regard to electromobility and hydrogen, would you say that it makes traffic safer compared to the combustion car?

**E3** [00:10:45] Whether the electric car is necessarily safer than an internal combustion vehicle? It really always depends. Hydrogen cars also have the issue of the tank. You have to make sure that it's properly compressed so that the hydrogen can't escape, otherwise it can be dangerous for the health. But because electric cars are always equipped with the latest safety systems anyway, and because autonomous driving is usually pre-equipped and connectivity is built in,

they are usually somewhat safer than combustion vehicles because of the technical equipment. But I think this is less due to the drive concept itself, but more to the technical equipment.

**Lennard** [00:11:28] Very good assessment. Perhaps we can then move on to what is probably the most important point in terms of mobility, the environmental aspect. Our two indicators are the combination of emission-free and circular economy. It is always said that alternative propulsion cars have no emissions at all, but only if they are powered by alternative energies. How do you assess that? Are they really zero-emission cars?

**E3** [00:12:02] In terms of local emissions, they certainly are, unless you take into account the emissions from braking and tyre wear. But from that point of view, the electric vehicle is definitely environmentally friendly when it's driving around. Apart from the lack of emissions, we don't have the noise that the electric car makes. Those are definitely advantages. But, as you said, you have to look at the whole chain, from production to disposal. The current situation is that, due to the demand for lithium and cobalt, we simply need a lot of raw materials that are mined in areas where there are many, many critical points. For example, very high water requirements to mine the rare earths. But also the social working conditions are anything but good in the areas where most of the lithium is mined. So there is definitely still a lot of catching up to do. Many manufacturers have already said that they no longer want to source lithium cobalt from these regions and are working to improve this situation. You also have to realize that electromobility has only been in the spotlight for a short time or less, and the whole technology still has to be given time to move in an ecological direction. Therefore, if you look at certain calculations, it is already the case that an electric vehicle, depending on how much you charge it with green electricity, is more environmentally friendly after about 70,000 kilometers than a diesel or petrol engine, sometimes even a little earlier. Of course, that always

depends on the individual factors. But you usually drive a car longer, more like 8 to 10 or 15 years. It is true that after 8 to 10 years, even with the current electricity mix, the electric vehicle will be more environmentally friendly than a combustion vehicle.

**Lennard** [00:14:20] So would you say that alternative forms of propulsion have a positive environmental effect?

**E3** [00:14:29] Yes. Yes, over the entire life cycle, definitely. If you really look at the electric vehicle after production, compared to the combustion engine of course, not yet. You always have to put that into perspective, also in comparison to a hydrogen vehicle, where we have the problem of how to get the hydrogen into the tank. The production of this green hydrogen is very energy-intensive and can be dangerous if it comes in contact with oxygen, so there are still many open questions. So I would say that the electric vehicle already has a lot of potential and has become even more environmentally friendly than it was last year.

**Lennard** [00:15:07] And also a higher effect than hydrogen, for example. Or also natural gas or Biogas?

**E3** [00:15:16] I don't have all the statistics in my head now, but basically, I have the greatest efficiency, especially if I charge the electric vehicle with green electricity. So I consume significantly less energy, if you look at the whole chain, when I operate an electric vehicle in contrast to an internal combustion vehicle, or a hydrogen vehicle. So from that point of view, definitely. And if you then get the manufacturing issues right and also the recycling capability in the next few years, which is currently around 70 % and is supposed to go up to 90-95 %

recycled material later on, if all that still takes place, then I think it will be difficult for other forms of propulsion, i.e. all the other alternative propulsion concepts, to keep up with that.

**Lennard** [00:16:14] Okay, all right. And in terms of the circular economy: do the concepts actually promote the circular economy? The drivers of electric cars often have no idea how they can recycle the battery in the end, what they should do best. I also stick to hybrids, i.e. with hydrogen, because there is actually no battery, they work with a normal engine. So are they easier to recycle than electric vehicles?

**E3** [00:16:50] I believe that electric vehicles offer the best opportunity to create a circular economy, because the topic as I said the most focussed on. It is relatively new and the entire industry is in a state of transition, and all the manufacturers and suppliers now have the opportunity to align themselves in such a way that certain parts can be reused in order to always create this cycle. The current level is 70 % recyclable, and in the future it will be closer to 90, 95 %. With electric vehicles, we simply have a very good starting point. And an example would be assuming that after 12 to 15 years the battery no longer has enough capacity to power an electric car, then the next option would be to use it as a stationary storage unit or as an intermediate storage unit or buffer at home in cooperation or in combination with a PV system, for example. So in the end you would have a huge battery that stores surplus energy, which would be an idea, to continue using the retired battery. And even after that, there are already possibilities being worked on to continue using the battery with even lower capacity. So I see this as a rather less critical issue with electric vehicles.

**Lennard** [00:18:45] And you also believe that the battery has a higher probability of being recycled than the electric motor?

**E3** [00:18:59] I can't really say much about that. My focus lately has been more on electric cars. So in the hydrogen vehicle we also have an electric motor, just like in the electric vehicle. It would be more interesting to know how the fuel cell car can be recycled, but I can't give an assessment on that. In the case of the fuel cell vehicle, our electric storage unit, i.e. where the energy comes from, is the fuel cell, but the electric motor is the same as in the electric vehicle. And that's where we would have to do investigate more. I can't make a comparison now.

**Lennard** [00:19:42] All good, that was also quite an interesting repetition for me to understand that fuel cells and hydrogen are not always the same thing, even if people often pretend, they are. Then we come to the last pillar, the Economic Pillar. And many people say that it is of course also possible that many large companies, especially in Germany, such as Volkswagen or Mercedes, which have specialized in combustion engines for 120 years, will be challenged by the change to alternative drives or new concepts such as Smart mobility. Because it is simply not their business, and then an entire sales division is lost. Which in turn would weaken the country's GDP. How do you assess that? Is it still possible to achieve a higher GDP or do you see it critically?

**E3** [00:20:51] Yes, I think that in principle it is feasible to further increase the gross domestic product. The important thing is to combine all the parts of the supply chain. As with everything, you simply have to integrate the topics that you want to incorporate well into the existing ones and optimize them. So the topic of electric vehicles combined with autonomous driving combined with shared mobility. That's the only way to get positive effects for the GDP. But it is true that we read and notice that German manufacturers are 3-5 years behind in the development of electric vehicles, hydrogen, and batteries. But it is also the case, for example,

that the whole issue of car manufacturers becoming software service providers is becoming more and more relevant. And you can already see that less money will be earned with the cars, but much more with other services. I can upgrade my navigation package over the weekend, or order seat heating in the winter and then cancel it again in the summer. That is increasingly happening by subscription. And that's where the great potential lies. You can save a lot of money, but you can also generate it, and you have endless possibilities. And if car mobility manufacturers manage to optimize these additional services and make them more interesting, they will of course earn more, which in turn has a positive effect on GDP. So, as I said, I'm optimistic about this, even if the market is shifting, of course.

**Lennard** [00:22:58] Okay, and just in relation to the issue of job losses. I have read an report from the EU Commission, which assumes that probably 6 million jobs in the EU are endangered by the whole conversion to green mobility. Do you see that critically or do you think that just as many new jobs can be created, because new concepts will be added?

**E3** [00:23:21] Yes, I definitely see that critically. I can address three issues in that case. Especially the retail trade and car dealerships. The need for service is decreasing, garages have less capacity utilization, and that is now the first profit factor. Oil will eventually disappear, and so on. In any case, these are points that have to be taken into account and I am not sure whether it will be possible to replace or compensate for all the jobs that will be lost, be it in car dealerships or at the suppliers or in production. What I do believe, however, is that the issue of consultants and services will become much more important and that new green jobs, as you call them, will be created there. But the question remains, how do you manage to transfer all the jobs one-to-one and provide the same number of jobs? But it is precisely in consultancy that

new jobs are being created, particularly in advising municipalities or advising companies that want to make the switch to smart mobility. And that will generate jobs.

**Lennard** [00:24:46] But do you think that jobs will really be lost? Or is it simply the case that many workers who now focus on conventional drives, for example, simply get a reskill, so that there is simply a shift, and no job lost?

**E3** [00:25:10] Yes, that is also difficult to answer, in the final analysis. This re-training, which is already possible with electric vehicles, is already taking place. There is not only the car mechanic anymore, but also the car mechatronics technician, and even in specialisations there is now always a parallel division for eMobility. So if you work in the car manufacturing, you can stay in this industry.

On the other hand, if you really look at the facts and realise that drivers of electric vehicles simply have to come less often to the garage than cars-owner because E-vehicles simply have less parts, you have the same number of cars but less need for workshops, which will of course lead to a reduction of employees at some point.

But again, you have to weigh it up. The turnaround doesn't happen overnight, it's a process. We do have very strong new registrations, about plus 10-15% of pure-electric vehicles each year, depending on which year you look at. But electric vehicles currently still account for less than 2 % of the car fleet. This means that it will take years before an effect can be seen, assuming a 15-year service life. An effect in road traffic and an effect in the workforce of the car manufacturers. And even after 2035, where the EU has just decided to phase out internal combustion vehicles. Of course, manufacturers worldwide will still produce internal combustion cars and deliver them to other regions. So you have to look at it a bit bigger. I think it's a very, very long process until you really feel these effects.

**Lennard** [00:27:04] All right, thank you very much for your assessment, that helped me a lot.

Then I would stop the recording now.

***Transcript Interviewee E4***

***--- Start of recording ---***

**Lennard** [00:00:00]: All right, let's start recording. Thank you again for taking the time. To begin with, we would like to ask you to say a few words about yourself or your career and then about your current activities.

**E4** [00:00:25] I'm happy to do that, I work at the German Biogas Association, so if you want any info on that, let me know. We are now 4700 people, which is really cool. We are a non-profit NGO, an association, and we have enough money from the membership fees of 4700 members to take care of 40 employees. 40 people who work on biogas issues in a highly professional way. Most of them are German operators, who are permanently advised, working groups, ISO STANDARD working groups for emissions, for protection, and so on. We also have various experts for licensing issues, for whatever. With me you have now landed in the International Department, for whatever reason. But still, I'm roughly informative. I've been in the biogas business for 20 years, worked as a researcher at the German Biomass Research Centre for four years, then as a consultant and now for eight years at the German Biogas Association. So, that's the general info from my side.

**Lennard** [00:01:12] That doesn't sound bad at all. Perhaps just briefly beforehand about the confidentiality agreement. We can gladly conclude or agree on that. Then you remain anonymous, and nothing gets out to the public, if you want.

**E4** [00:03:16] We don't need it guess, you can also quote me, like Frank Hofmann as an expert says this and that. That's no problem at all. It's just that when it comes to political assessments

of mobility, it might be better if you don't refer to me as an official professional association biogas position. Here I will simply share my personal assessment or something. Yes, but we don't need to write anything down.

**Lennard** [00:03:52] Cool, let's get started straight away. We have chosen the two indicators Accessibility and Safety for the Social Pillar. And here's the first question for you: Biogas is really something very specific. Many people have probably not even heard of it. Is it an alternative at all? So do people have access to it or is the topic simply still too unknown?

**E4** [00:04:43] It is certainly accessible in the mobility sector, because biogas is a mixture of methane and CO2. These can be separated through biogas processing. Then you have practically pure methane and there are methane filling stations. It is used in private vehicles, mostly in the form of CNG, or Compressed Natural Gas. There are various CNG filling stations and that's why it's quite accessible to ordinary people! That means excessive accessibility, in any case, if you are aware of it! Of course, not everyone in Germany knows that there are CNG vehicles, but especially in rural areas people are well aware of it. Especially in rural areas, it's more exciting for the people themselves, because I often hear from farmers that they are proud of their own energy production, because there are also farmers who have a CNG tractor, for example. So if we look at the whole range of technology, there is complete natural gas being used in Sweden, in trains, sometimes in buses, in Berlin, the BSR. Half of the BSR fleet, that's the Berlin city cleaning service, are CNG vehicles. By the way, it's a very interesting project, because the organic waste we collect at home is brought to Ruhleben, fermented there, processed to natural gas quality, and then used for the vehicles that collect the waste. Then you have a very nice recycling effect. Both energetically and materially. So the energy from the waste is used to collect waste again. All the nutrients that are recycled by the plant come out in

the end as ger products and can be reused in the fields. A super recycling effect. But we'll come back to that later. All in all, I would say that the accessibility is definitely there.

**Lennard** [00:07:04] Okay, and perhaps a very brief question about this: Where can I actually fill up with biogas?

**E4** [00:07:13] There are quite a few petrol stations that offer CNG. I don't have a vehicle myself. The German Biogas Association has one and they always have an app where you can see where the CNG filling stations are throughout Germany. And these are quite normal, typical filling stations where you also buy petrol or diesel. But not all of them have that yet.

**Lennard** [00:07:37] And how many petrol stations are there already in Germany?

**E4** [00:07:39] In Germany? No idea, but it's easy to google. CNG filling stations in Germany.

**Lennard** [00:07:49] What road safety risks do you see with biogas?

**E4** [00:07:56] So actually for refuelling, I've heard there are practically no additional risks. I know that a few years ago there was a problem with a car bursting into flames. But basically, it's just like filling up with petrol. The only thing is that these CNG cylinders have 200 to 250 bar, so there is a lot of energy in the cylinder and it shouldn't blow up. On the other hand, the safety requirements in Germany are very strict, so I rarely hear of accidents.

**Lennard** [00:08:42] And what about the flammability of biogas? For example, if you have an accident and the gas leaks out, does it catch fire easily?

**E4** [00:08:53] If I just think about it plausibly now. If a normal vehicle has an accident, the petrol or diesel leaks out and then it can burn. CNG in my mind goes into the atmosphere and is then quickly gone. That's often the case with biogas plants, too. If something burns there, it doesn't explode with a huge bang or cause huge pressure waves. There is at most a small jet of flame, but that is not an explosion but rather a deflagration. And that's what I would expect from a car like this. After an accident and petrol or diesel leaks out, that seems much more dangerous to me.

**Lennard** [00:09:42] Okay, that's a good assessment. And what about methane? If you breathe it in somehow, isn't it harmful to your health?

**E4** [00:09:52] You would have to breathe in a lot to displace oxygen. Basically, you have a certain health range. You have oxygen in the atmosphere, I don't know whether it's 20% or 21%, and there's a lower limit where you get asphyxiation. But CO2 displacement is more of a problem. Methane is lighter than air and escapes into the air. So actually I don't think that could be a problem. By the way, lighter than air is actually quite relevant. So let's look at it from a practical point of view without reference to mobility. If you have to maintain such a container from the inside, they are huge, often 1000 cubic metres, 10 metres high or so. When you have to climb in there and take out the material. The CO2 that collects at the bottom is dangerous. You need breathing apparatus. But since methane is lighter than air, it immediately escapes upwards, and that's what I would expect from a car.

**Lennard** [00:11:05] Okay, interesting. Maybe a quick question for me: can any car theoretically fill up with biogas or do you need a specific tank for it?

**E4** [00:11:14] You need a specific tank. Well, that's relatively easy to retrofit, but usually you also have a special tank. So a pressure gas bottle is in the back and in the boot. Then you need this supply line, which has to be made. So you can retrofit it, but you actually have to buy special CNG vehicles.

**Lennard** [00:11:39] Very exciting assessment, many things I didn't know yet.

**E4** [00:11:44] And I can even think of something else. In addition to pure CNG, there is now also a trend towards LNG, or liquefied natural gas. Biogas, i.e. pure methane, can of course also be liquefied, but this is less relevant for small passenger transport and more for heavy goods transport. And that brings us to another point: it is of course extremely difficult to really electrify mobility in the case of heavy goods transport. Or let's think about ships. That's where LNG is increasingly stepping in, which you can then use for heavy goods transport. Up to now it has mostly been natural gas, but of course methane can be liquefied as well. And there is indeed a great tendency in this direction. So there are the larger manufacturers, Shell is quite active there and IVECO as a manufacturer of vehicles. And they are definitely interested in not only using natural gas, but also a green gas, and biomethane is an obvious choice.

**Lennard** [00:13:10] I have actually also read that this is an alternative for trucks. So I have learned a lot there. Let's move on to the next point, the Environmental Pillar. There our indicators are, decarbonisation and circular economy. And the most important question, which is of burning interest to me, is: Is biogas really emission-free?

**E4** [00:13:45] It depends very much on the substance used! The principle of bioenergy is as follows: CO2 is in the air at a certain percentage, I think we are at 400 ppm at the moment,

maybe just above. The single CO2 molecule is absorbed by the plant and incorporated in the plant in the form of carbon compounds. So as fats, carbohydrates, proteins and so on. These are then stored in the plant. If you were to burn the plant, CO2 would be released again. But its basically exactly the same amount of CO2 as the plant originally absorbed. This means that it is basically emission-free to begin with. In the biogas plant, methane and CO2 are now produced. They are burnt, the methane is burnt. CO2 then comes out of the chimney of the biogas plant. But it is again the same amount of CO2 that was originally taken out of the atmosphere by a plant.

But there are also other effects. If I want to build the biogas plant, I need a lot of steel, a lot of iron parts, copper, whatever. That means that the production process first needs a lot of energy, as does the operation itself. People have to work there, etc. This means that in the plant itself you will have CO2 emissions. There are also various life cycle assessments that examine this in detail and the result is more or less that the input material is the decisive factor! But now comes the exciting part. One is energy crops, which are only cultivated in a few countries, i.e. Germany, Austria, the Czech Republic. Few countries have promoted it. But in almost all countries the use of waste as energy producer is increasing. In life cycle assessment, waste is practically equated with zero emissions, because CO2 emissions are allocated to other areas, for example food production. And the most exciting thing is, if you can avoid methane emissions. And now we come to manure-processing plants. If I have livestock farming, for example: the manure is stored, and these are enormous methane emissions. The biogas plant itself is a closed system. The system works and reduces the release of methane emissions. And through that we even have zero emissions, which means a lot of biogas plants are able, if I look at my life cycle assessment, to provide negative CO2 emissions, and therefore to provide fuel that is produced in such a way that it even has methane reduction. And that is then not only climate neutral, but even climate positive.

**Lennard** [00:18:41] Would you say that the biogas car is probably even better than the electric vehicle and the hydrogen vehicle?

**E4** [00:18:48] Yes, much better, of course. So electric vehicles, when I look at the battery, the production of the battery, a lot of electrical energy goes into it and certainly not just green electricity. The biogas plant is much better, and it can also be negative. No hydrogen can do that, and neither can EVs.

**Lennard** [00:19:19] What comes out of a biogas vehicle as emissions? They probably don't have an exhaust?

**E4** [00:19:26] Yes, they are normal combustion engines, i.e. gas engines. Basically, you can even convert diesel engines relatively easily and it is CO2, traces of substances that also occur in diesel engines.

**Lennard** [00:19:45] And then they come out of the exhaust?

**E4** [00:19:49] Exactly.

**Lennard** [00:19:50] All right. And maybe one more sentence about the Circular Economy. So you just said that some of the waste can often be recycled in the fields?

**E4** [00:20:02] Right! As fertiliser!

**Lennard** [00:20:03] Yes, maybe you can say one more sentence about what effect that might have.

**E4** [00:20:10] So it has a very big impact, because if you imagine a typical biogas plant has many 1000 tonnes of organic materials that it processes. And accordingly, only a certain amount goes out in the form of gas. But a very large part of it is a fermentation product, which is taken to the fields and thus has an enormous fertiliser effect, and you can save on mineral fertiliser. And then there is what I have already said about the BSR here in Berlin. With biogas, all the typical minerals, such as phosphorus, sulphur and so on, are returned to the farm.

**Lennard** [00:21:32] Exciting. As I said, I have already learned a lot, so it was the right decision to invite you to our small circle of experts here. So let's move on to the next pillar, the Economic Pillar, which is about GDP growth and green jobs. Now, many people say that if we have biogas, for example, then all the big car manufacturers like Volkswagen or Mercedes are at risk, because they can't change their product ranges so quickly. Do you see a risk for the gross domestic product of countries like Germany, for example, due to increasing biogas technology?

**E4** [00:22:09] I can't say anything about the automotive industry, because I don't know what it means for the automotive industry, what kind of things they can save or not. What I do know is that the biogas industry itself is more of a job creator. There are also figures on this, but for some reason I can't send them to you in the chat at the moment.

**Lennard** [00:22:54] As I said, you can also just send it later by email.

**E4** [00:22:57] I can send it to you, because it describes a few figures for jobs. Yes, in principle, there are 5,000 jobs in the biogas sector at the moment. That means that biogas energy production is really a job creator. This is also true internationally. The keywords are always rural development and job creation. You see 50,000 jobs in Germany. That is much more job intensive than compared to conventional energy production like coal-fired power plants or gas-fired power plants or something, I'll send you the link later. What that means for the car industry, I have no idea.

**Lennard** [00:23:51] Okay, good, but overall, it sounds as if many new positions could be created through this new or this area.

**E4** [00:24:01] In any case.

**Lennard** [00:24:04] Cool. And what effect could this have on the gross domestic product of a country, do you have any information?

**E4** [00:24:11] Also in the industry figures I sent you. You can read about the €11 billion turnover in the biogas sector on the last slide. There you also have some figures on the development of biogas, which has been around for over 30 years in Germany and how many plants there are and so on.

**Lennard** [00:24:30] Cool.

**E4** [00:24:31] A 11 billion turnover, almost 50,000 jobs, that's quite a number.

**Lennard** [00:24:36] That is the case, and it is also more than what I have read or heard so far about other types of drive. So I think we have found our clear favourite here for the transformation process in the automotive industry. Very, very exciting insights. Many, many thanks, Frank. It was very interesting, and I also learned a lot. I would now stop the recording.

*Transcript Interviewee E5*

*--- Start of recording ---*

**Lennard** [00:00:00] All right, the recording is running. Let's start right off the top with the Social Pillar, in terms of electric mobility. I've heard over and over again that the technology challenges accessibility in rural places in particular, because these locations often doesn't have the charging infrastructure yet. How would you assess that? Is that still a problem? Or what is the current situation with the charging infrastructure?

**E5** [00:00:29] OK, you're writing in an EU context. Yes, I can tell you how it looks in Germany. I think that we have a very, very good situation in Germany in terms of public charging infrastructure. I was in Oslo last year in October and looked at the topic of mobility and charging infrastructure. When I looked at it, I think, and I'm sure you'll see this in many places in the opinions of other experts, that we have a very, very good, very well-developed public charging infrastructure overall. So especially when you have to charge because you drive long distances on highways, etc., you are really well positioned. We always have very funny discussions in the group, i.e. in the car dealerships, because the companies in rural regions say that the charging infrastructure is much better in the cities. And those in the cities say: Yes, in the cities you have a much worse charging infrastructure than you have in the countryside. My opinion is that the topic of charging infrastructure should not be limited to public charging, but that you have to look at the situation of private individuals, or in the commercial sector it is often a combination, because many take their company vehicle home. You always have to look at where I charge my car, which I park at the end of the day. Because actually you only need this public charging and fast charging if you travel long distances and have to charge in between. Otherwise, you don't really need it at all. Because in the future, vehicles will have such a long range that you will be

able to do your daily workload with the battery, with the range. And people who live in the countryside are much more likely to have the space and the area to set up a charging infrastructure. And in this respect, I believe that this is more of an excuse that the situation is worse in rural areas than in the city! Because if I look at the city in Berlin or, for that matter, in Lisbon, wherever I have many flats and few parking spaces, in places like that you have a much greater challenge to build a charging infrastructure. And I see a much bigger challenge there. Even in business locations. I'm thinking of the MBVD, for example. We have the large multi-storey car park on Mühlenstraße. And next to it is the Mercedes Arena. And in this multi-storey car park, although the entire MBVD parks there plus Zalando, and you don't have one wallbox! And you have to create a charging infrastructure at the company location where you can charge publicly. Or the employees take the cars home and have the charging option at home.

So one is the availability, the other is I think that public charging is not lucrative today from an economic perspective, especially with the rising electricity prices! If I were a private person, I'm looking at my neighbor now, he has no interest at all in public charging because it's far too expensive for him compared to the kilowatt hour he charges at home! In this respect, I believe that it is not only a problem of creating charging infrastructure, but ultimately also a question of cost structure. Because otherwise, I think this will come up again later, electromobility will prevail! And that also has something to do with consumption costs. I once made a comparative calculation: filling up with diesel for €1.80 per litre at €0.40 per kilowatt hour. Electric mobility is still worth it! But nowadays you can hardly find a charging station in public where you can charge for only €0.40, you have to pay more. In my opinion, this could be solved in the same way as with mobile phone contracts, this roaming, when you are abroad a home tariff applies, and in my opinion this could also be done with the electricity costs for public charging stations. That you pay the price you pay at home also at public charging stations. Especially because industrial electricity is actually much cheaper than electricity at home.

**Lennard** [00:06:52] That means that electromobility per se does not exclude any social group, or at least not people living in rural areas?

**E5** [00:07:00] Well, if you say that from tomorrow you will no longer be allowed to drive a combustion engine, like in Paris, for example, where no more diesel cars will be allowed from 2024. If you were to do that for Berlin, then of course you'd have a problem, because there are many people who can't suddenly afford an electric car from one day to the next! So in this respect it is already an issue! There are many who can't afford it at all. Quite apart from the fact that there is still the question of where do you change your car? Especially the socially weaker don't have their own private houses, don't have a wallbox, I mean I had one installed myself at my own expense. You're looking at 1,700 euros. You have to be able to pay for that first! And I don't think that's going to work at the moment. So it's already a hurdle. Plus that the subsidies for the purchase of electric vehicles will be limited from 1 September, first for businesses, and when the pot is empty, then at some point also for private individuals. And then you simply have even higher acquisition costs! So I think that, from that point of view, an electric vehicle is currently still a hurdle, plus the rising electricity prices!

**Lennard** [00:08:51] What would you say in principle? Is it more expensive to drive an electric car than a combustion engine? In the long term?

**E5** [00:08:58] It depends on where you charge. Otherwise, I say: currently no! It's not more expensive, it's even cheaper. OK, so this example I gave earlier with the electricity costs of €0.40. I had this discussion with my neighbor, because he just bought an electric car and is now struggling with the electricity prices. So at €0.40, as I said, it's still cheaper than a combustion

engine. If I say I'm going to buy a new combustion engine or I'm going to buy a new electric car, I have to take the consumption advantages into account. Plus no car tax plus the GHG quota. We have integrated a maintenance package for four years into our cars. I have to take all that into account and then an electric car is still cheaper today.

**Lennard** [00:10:16] Exciting assessment. Then perhaps directly to the next indicator, the reference to safety. What would you say are the safety risks of an electric car for people and nature? Especially in the event of an accident?

**E5** [00:10:28] The risks are exactly the same as with the combustion engine. The only thing that is difficult is when the vehicle burns. But the risk of it burning is no higher than that of an internal combustion engine. You have the same risks. You just shouldn't touch anything with an orange cable, because we're talking about high-voltage systems. You have to watch out for that! But you don't have a higher risk with an electric car compared to a combustion engine.

**Lennard** [00:11:07] Okay, and if the vehicle does catch fire anyway, there's this one spectacular video from Tesla. How do you rate that?

**E5** [00:11:17] That is highly critical. If a vehicle like that is on fire, you can't put them out so easily. There are special procedures for that, because you actually have to flood the car. There are special containers where the car has to go in and then it is flooded with water, because otherwise you can't put it out because of the heat generated by the battery. You come from the service sector and there is the issue of occupational safety and work safety for service, and in this context, there are concepts for electric vehicles, especially for critical batteries, or conspicuous batteries, damaged batteries. So transportable or not transportable. And there are

special workshop concepts, building concepts and storage areas and the related recommendation that the companies purchase containers where you put the car and have access at the top where you can connect the hose and flood the container.

**Lennard** [00:12:36] It's interesting that you don't think the dangers are higher than with an internal combustion engine. I had read something different, but that's good to know.

**E5** [00:12:45] Yeah, no, I don't think so!

**Lennard** [00:12:47] Then perhaps the big question that interests me most personally. Would you say, in terms of environmental friendliness, that an electric vehicle is really more environmentally friendly than a combustion engine?

**E5** [00:13:03] There are already analyses today that show that an electric car consumes significantly less CO2 than a combustion engine. So over the running time! Yes, but it is of course the case that today's battery and the associated generation of raw materials have an impact. This is very CO2 intensive until the battery is produced, including transport routes! Nevertheless, over the life cycle and the burning of fuel compared to green energy or today's energy mix, which already contains over 50 % green energy. If this is ever 100% green energy in the future. Then it will at least be locally emission-free. And that has a huge added value So you only need to focus on production processes, so how CO2 neutral can you make it. Quite apart from the fact that the newer generation of batteries, for example, no longer contain any lithium, but are so-called solid batteries that no longer contain any lithium. So in this respect, you no longer have the mining of raw materials to the same extent.

**Lennard** [00:14:52] But can we assume that at some point there will be batteries that are made entirely from renewable raw materials? Or will we always need a certain amount of cobalt, lithium or whatever?

**E5** [00:15:04] Well, as I said, you no longer have lithium in a solid battery, but of course there are other substances. The basic idea is that you have a battery that is in the car, which is driven and driven and driven and it is assumed that the battery will be broken after eight years. That's nonsense, the lifespan of a car battery is much longer. With a battery certificate, we only guarantee that 70% of the power is still guaranteed after eight years. But that doesn't mean that this is the case. And if it's not, you get a new battery. But experience shows - and Renault, for example, has also evaluated this with the ZOE, which has been around for a long time - that the battery capacity is still so high that it can be used beyond the eight years.
Should the battery capacity decrease, the batteries will be used for their second life cycle to act as temporary storage. For the energy transition, they store surplus energy, which is then made available again when energy is needed. So in principle it's a second storage unit. And then comes the recycling cycle. So there are certain processes for recycling a large part of the battery. There is a thermal process and a mechanical process to separate the raw materials and reuse them. However, this is not related to the product! The goal is to develop processes that separate the raw materials from a recycled battery in such a way that you can put them back into the battery cycle. That's the idea. But that is still the future. We're still developing that, we're still a long way off. Even if you look at the funding programmes of NOW, for example, there is a lot of emphasis and money being invested in developing processes to do this. But today you still don't have many batteries that go into this recycling world, unless they are defective. So accident batteries. And so on. But batteries that are being phased out because they don't have enough capacity to run a car anymore and they don't have enough capacity to be used as temporary

storage. That will take a while. But that's basically the idea of the cycle, how to deal with the batteries.

**Lennard** [00:18:37] Exciting. There were already many points on the next topic, the topic of Circular Economy. Perhaps just one more very brief question, because you have already said a lot about it. How long will it still take? That batteries can really be completely disassembled into their components?

**E5** [00:18:56] I don't know. Because it's not my field either. At least another five years, I would have said once.

**Lennard** [00:19:06] That would be very cool.

**E5** [00:19:13] Yes, yes. The question is whether the battery technology will change by then. But even a solid-state battery doesn't need any more lithium, which has to be mined. But at the end of the day, even the solid-state battery will have to be recycled at some point, because it no longer performs.

**Lennard** [00:19:42] Then lets move on to the last pillar of the Economical Pillar. Let's start with the keyword gross domestic product. I once read in the article that many companies feel challenged because they say: Well, an electric motor has only 1/10 of the components of a combustion engine and therefore we actually only need 1/10 of the workforce. That is a challenge. Couldn't that also apply to Mercedes, for example?

**E5** [00:20:13] So of course you have other productions. You can see it for example in the Berlin plant, which is an engine parts plant. They produce engine parts like camshafts, crankshafts and so on. Water pump, oil pump. You won't have these factories tomorrow! They already have the challenge. They are now starting to retrain workers from the assembly line, so that they start programming, so that new job profiles arise. So it's already a challenge that certain jobs are simply being eliminated because the products are changing. Or through the topic of digitalisation, you have fewer productions. In this respect, you may need fewer people who are definitely focused differently. For the workshops, it has a big influence because maintenance intervals are no longer as frequent and you basically no longer have so many activities. But you have other activities and that doesn't mean that it will be cheaper for the end consumer, because you need more specialised workers! So it's no longer a case of oil and bolts, but you have the electricians and diagnostic technicians. But above all, you have the cash cow, the engine oil, which is no longer needed! So purely from an economic perspective for a car dealership, the big margin issues just fly out. So that is already an issue!

Yes, otherwise there will be new business models again! For example, you suddenly have a product like charging cable inspection. And these are new activities that have not yet been implemented in the company. And that's how new opportunities will arise. But at the moment it is seen more critically that the margins are falling away! That's why, for example, there are many companies that are focusing on building a charging infrastructure at the car dealership and then equipping it with a PV system and selling their electricity. So these are new business areas that are emerging.

**Lennard** [00:23:21] And in terms of GDP, there are many articles saying that there are other countries, such as China, that are already a bit more advanced in terms of electric mobility. Do

you think that they could perhaps have an influence on the German market and thereby perhaps also challenge old companies in Germany?

**E5** [00:23:48] Well, you automatically have that with the products. The Chinese have quite a few vehicles on the market, new players, some of which are now spilling over onto the European market. I'll take BYD as the most recent example, which is coming onto the German market. And that automatically means you have competition. And I believe that electromobility also writes other laws. Our visit to Norway had also brought this back to us. The entrepreneurs in particular said that range beats brand. Today, many people have a loyalty issue like, for example, I only drive Mercedes. But if there are vehicles from brands that have a higher range, faster charging cycles, i.e. everything that goes beyond topics like all-wheel drive or trailer coupling, then customers are more likely to buy the vehicles than to say, I'm only attached to a Mercedes. And that can also happen with Chinese products, of course. Customers say: they have a longer range, they can charge faster, so if the technology is better and the price is right, then it's a threat to the German market. At the moment, the Chinese are making a mistake. Dudenhöffer once said that they are coming up with vehicles that actually have competitive advantages in terms of the product, but they have the wrong price positioning. And so the Europeans or the Germans are not prepared to pay a similarly high price for a new non-European product compared to the Germans. But if they were positioned differently in terms of price, this would pose a much greater threat.

**Lennard** [00:26:25] So if you were priced cheaper probably or?

**E5** [00:26:27] If they were cheaper. Exactly. And so so and so NIO is also offered at €60,000, even though it might only be offered for 30,000 on the Chinese market.

**Lennard** [00:26:40] All right, then the last question, you had already mentioned it. Do you think that mobility will create more jobs or that more jobs will disappear?

**E5** [00:27:06] I think it will be a mix of everything. Existing jobs will disappear, jobs will be reallocated in the factories, as I said. But completely new business models will also emerge. So, for example, the topic of bidirectional charging alone, there is the activity that manufacturers will also become electricity suppliers and use the car batteries as intermediate storage and start trading electricity! In other words, buying electricity cheaply, then putting it in the cars and storing it. And when the price of electricity is high, because it is needed at the moment, that electricity can be taken out again, and new players are establishing themselves in the market. VW is already doing this, too, in that they become electricity suppliers but actually only buy the capacity of the battery and you, as the vehicle owner, sign a cheap electricity contract with them, get cheap electricity, but in the end make your car available so that the companies can trade electricity. So and so, this is an example of where completely new business models can go.

**Lennard** [00:28:36] Very good, what would you say, does electric mobility actually make sense for trucks or is it only an alternative for cars?

**E5** [00:28:49] I can tell you what the strategic orientation is at the moment in politics and also from the car manufacturers. And there is clearly e-mobility in the direction of cars and vans, and hydrogen is then in the truck sector. Many say that e-fuels and hydrogen are the much better option. At the moment it's just that this variant would be too expensive. So maybe it is more efficient in our minds. But we are not a country that can produce hydrogen cheaply. Maybe that

would be the case in Africa in the Sahara, or in Asia. In the desert, yes, you could do that. But then there's the problem of logistics. I mean, we have a great network of petrol stations. But how does the hydrogen get there? And I once heard that you could only charge 18 cars with one tanker of hydrogen. So that's nothing. So at the moment it's just not efficient. I'm curious to see what happens with e-fuels, because that's not a solution from a cost perspective either. It's not an economic solution or affordable for the user.

**Lennard** [00:30:26] All right, thank you very much for your time, I'll end the recording with this

***Transcript Interviewee E6***

***--- Start of recording ---***

**Philip** [00:00:03] So I would start with the recording now. And I would jump right into it with the social pillar where we derived the indicator of accessibility. Under accessibility, we understand the connection of rural areas to the mobility infrastructure as they are mostly right now, not very well connected. We also looked at the affordability of the mobility solutions, and how this could be impacted. So maybe you could start with smart mobility as a concept if you think that could have an impact on accessibility or affordability?

**E6** [00:00:36] Yeah. And again, like, are we defining smart mobility as public access, public mobility, or shared independent mobility and micromobility? Depending on what's included in the definition of the term, the complexity of the topic rises. Also accessibility might actually be hindered as you've got, people living with disabilities, elderly, and the question if they can actually use the micromobility vehicles, bicycles, etc.. and if they feel safe using it. And also, does it actually help versus public transportation?

I'm in an area where I see autonomous vehicles being tested daily. I've been seeing a lot of the work and conversation in rural areas being around public transportation solutions. Even if it's autonomous public transportation, the things that can actually move more people, are also going to create healthier infrastructures because then you're not centering the infrastructure on multiple vehicles, you actually can create healthier communities and connectivity and accessibility and lower the costs. Because then we're looking at a public good competing with private companies.

**Philip** [00:02:26] Our focus is kind of on the automotive industry. So, we focused mainly on the car sharing model. But yeah, very interesting insights. And just a follow up question, if I can ask on which level are you operating on the autonomous driving right now? Like because there are five levels defined according to my research so far, right?

**E6** [00:02:47] Oh, like what I see here, like in San Francisco?

**Philip** [00:02:51] Yeah, yeah, yeah.

**E6** [00:02:52] Well, so I got, I live in an area where I walk down the street and you will see autonomous vehicles.

**Philip** [00:03:00] Oh there are actually already in use?

**E6** [00:03:02] Yeah. And then sometimes with a driver and sometimes without. There are lot of companies implementing it, Cruise being one of them. And there is a lot of funny and weird things happening, funny to like, oh, my God, like, we're landing into busses, things like that, stopping in the middle of the intersection like it happened with Waymo. We've got all this stuff and we see it all the time.

**Philip** [00:03:30] So yeah. But there's always still a driver in the vehicle right?

**E6** [00:03:35] No, not always. Fully autonomous.

**Lennard** [00:03:40] I have just a quick question to this. Are all of these autonomous vehicles electric?

**E6** [00:03:45] Yeah, yeah, all of them are electric. Yeah, I think. No, I think there's one that might be testing with a driver. No, I think they're all electric.

**Lennard** [00:04:08] But not hydrogen. So they all have are driving with the electric batteries?

**E6** [00:04:13] Yeah, yeah, yeah. So it is. Yeah.

**Philip** [00:04:18] Okay. Nice. Thank you. And then just, adding up to this question on our other concept, if that can also have an impact, maybe especially on the affordability, if we look at electric mobility?

**E6** [00:04:32] So, with affordability I think it can actually go down when you can actually have more shared space regarding bigger vehicles like vans or mini buses. You can already within a small vehicle, have shared mobility and have more affordability, which creates more access. But if you actually couple that with a little bit of a bigger vehicle that can actually have more people sharing the costs. So, I think affordability starts going down a) the more people will be open to share their vehicles and b) if you actually make the size a little bit bigger. But also affordability concerns the last mile and public transportation instead of connecting rual area to city or you know village to city, you could connect the village to the mobility hub. Therefore, the goal will be to create as much access points to different kinds of transportation as possible and the focus should be on the last mile. The first of the last mile.

**Philip** [00:06:05] Mm hmm. Yeah. Thank you. Very interesting. The next indicator we found for social pillar was safety. So, we looked at safety on the roads and also included the safety of the employees in the supply chain. And maybe you can also tell us if you think the smart mobility concept could have some impact on that?

**E6** [00:06:30] Yeah. And that and that's kind of complex. So, safety on the roads by a shared mobility driven by humans or autonomous or both? And regarding autonomous driving the truism is we're not going to reach full autonomous vehicles only a very, very long time.

**Philip** [00:06:55] If you say very long time, do you have some estimations? Like when do you think it would be applicable?

**E6** [00:07:03] I actually talked to some really interesting people who are building a startup and instead of autonomous vehicles, you have assistant driving. What they do is instead of having full autonomous vehicles, you have remote driving, so you have a real person behind a computer remotely driving a car. A person can get into the car and drive wherever they need and then they can drop off the car and it will drive off. But it's remote driving versus autonomous vehicle for the reason of safety. So, I think there will be some distinctions made as you're talking about safety. So, you know, there's one side of like a person on a shared mobility driver as the employee's safety. We're seeing in San Francisco, that we're actually having more congestion because everybody wants to get in the gig economy instead of our expectations that we will have less congestion if shared mobility is increased. And all of a sudden you have more cars on the streets. Yes, they might be EVs, so you might not have the same impact on emissions, but congestion is still a problem for safety. We still have tires which lead to a form of pollution. Talking about the supply chain which increases the production as we need more cars and also

then the emission in the production process. So we're all we're all of a sudden moving the problem from of tailpipe emissions to back to like, you know, origins of it regarding the supply chains. It also shows the safety issues complexity.

**Philip** [00:09:27] So actually, in practice, you saw that the cars number increased when increasing share?

**E6** [00:09:34] Yes in San Francisco that was actually the case. And you can actually do the research on like you know what they thought would happen and like what actually happened in actuality. They actually thought that less people are going to use cars what happened and I think it's also the pandemic is that there are less people using public transportation. More people are using either shared mobility or their own cars. So the net result is more cars on the street.

**Lennard** [00:10:09] Just could you sum up ion a quick sentence about. What oyu think about the videos where batteries from the electric vehicle are getting in flames. Regarding these accidents what's your opinion on the safety of EVs?

**E6** [00:10:25] Yeah, well, each company has done their own test. Tesla has had some issues with their testing. There are reports of a lot of recalls on the cars and also the whole releasing the autonomous (autonomous feature) without any kind of safety precautions actually led to a lot of deaths, not huge amounts, but enough to get into the news, enough to create backlash. I think as we see more adoption like regular vehicles, the scrutiny over safety is going to go up. But then, you know, there is the safety of the technology itself, like is the battery going to explode and there is going to be regulations around that. And then there's just, you know, who are we prioritizing streets for humans or cars? And I think that's also a question of safety. And

you see it in the reimagining of urban environments and moving towards some settings, towards more, you know, bike friendly micromobility, zero emission zones, because when you have less cars on the streets and more people on the streets on bicycles, actually the harm is less extreme because you can still get pretty hurt falling off a bike or being hit by a bike, but usually it's not as extreme as a highway accident. So, I mean, I know there are studies out there around that was kind of like giving a pointer. And when you start looking at things.

**Philip** [00:12:28] Okay, perfect. And then I would just jump to the next pillar, which would be the environmental pillar, and we also talked a bit about it already. The first indicator we found was the decarbonization, and with that we meant a lowering of greenhouse gas emissions, but also at the same time increasing the usage of renewable energies. And again, maybe just with the two concepts, you can say what impact you think smart mobility would have and on the other hand, and the technology of electric mobility and hydrogen?

**E6** [00:13:00] Yeah. And again, it is complex, right? Because we do want to move all vehicles into being electrified and it's absolutely the right way and in not only my opinion, the UN , IPCC, that everybody agrees that this is the way to go. But what are we prioritizing for mobility and what's the scope of getting there? Because we cannot decouple the renewable energy from where we are sourcing the materials and the supply chains and also what happens to them at the end of life. Like can they actually be recycled, kind of be upcycled, etc.? There are emissions, and there are conversations about the circularity. And the same thing with, you know, that was my question. When you talk about automobiles, spefically shared mobility, does everyone has to change to EVs? Well, that will take a lot of resources. So how do we do that like that? If you get that car on the road and yes, it does not pollute as much but you have all this other pollution in the supply chain and then when a car is done, you have got the batteries, you've got all the

plastic, all these things what happens at end of life. So I think there has to be a more holistic way of looking at emissions from the supply chain and the whole process until the car is on the road and cannot be decoupled from like, oh, we're not polluting right now. By the way, yes, they are findings that at the end of the day an EV pollutes less throughout the supply chain than a gas guzzling car for sure. But there's other aspects. The dwindling resources to even build an electric vehicle or build the battery or built the renewable energy plan, solar, whatever it is. So I think there is a space for also what's the next evolution of all these technologies in a way that reuses the technology, really brings in circularity into all this conversation. So the thing about circularity is if we don't actually think about circularity from the scratch on, we're leaving money on the table because there's so much money and resources that we're wasting. And so how do we actually think about it smartly as we move forward to developing these technologies and these mobility hubs, etc.?

**Philip** [00:15:52] Mm hmm. So so in general, you would say that they would have a positive impact on implementing circular economy?

**E6** [00:16:05] Yes if done right and thought through.

**Philip** [00:16:07] And just the last pillar we would be the economical. And there we have the two indicators of the GDP and the creation of green jobs. And for the GDP, we try to indicate if the concepts could result in a cost reduction in the supply chains. Or these technologies could actually help the countries that are implementing the technologies to be more crisis resistant. So maybe you could say something to that as well. Or do you have an opinion on that?

**E6** [00:16:41] Yeah. First, I would send you to read a wonderful and very important book for all of us, which is about economics. And there is a chapter specifically about GDP, because GDP globally is going down. But there's a lot of opportunities in circularity to actually mitigate some of the falling down because we're looking at the accounting ledgers in the wrong way. We're not accounting for all the resources we actually can reuse and upuse. There are spaces existing the retrieval, the upcycling, new technologies. So there is a lot of space for economic development and green jobs. There are new jobs that we don't even know about yet. So I think even looking forward, like, what are these new jobs e.g. EV technicians, mechanics. As the cars are getting more sophisticated you need to actually understand how to use very sophisticated technologies. So upskilling of the workforce will play a big role in this. Other kind of green jobs could be in building up the charging infrastructure and also training people how to use that infrastructure. And then because it's great to start something, but then what is the maintenance jobs that are going to be showing up for these technologies? And there are going to be a lot of them. And also I think there is a there is a space for retrofitting. We're going to learn retrofitting in order to upgrade to the new technologies without needing to go and buy a new car which could create a whole new industry locally and globally? So there are thoughts about not only in the transition period for the next three years, but what happens ten, 15 years down the line with these technologies and how to eliminate the creation of waste as much as possible and implement the reusage of resources.

**Philip** [00:19:14] Mm hmm. So as you also mentioned, the upskilling of the workforce, do you think in general that more jobs would be created or also a lot of jobs will be lost? Like in total, if we were to draw a line in the end?

**E6** [00:19:29] Yeah. I mean, we're facing a lot of automation due to technologies like AI but there's also going to be a lot of new jobs. So we don't know where it's going to go. That's where the conversations around concepts, like UBI (universal basic income) can come into play because there will be lots of people that might be not able to get jobs in these new technologies, like what do we do? But there's actually a concept called the useless generation, which is kind of a scary concept. So what do we do with people that cannot fit in the new job world that we have. So that's again, that's a societal macroeconomic problem. So yeah, there might be some amazing jobs and there might not be.

**Philip** [00:20:27] Okay. So you would more see the problem in the upskilling of the workforce. But the jobs will be they're just not the qualifications of the workforce?

**E6** [00:20:35] I think we're going to lose a lot of jobs. We would need innovation in our social networks and we will we need to upskill just in the end the question will be if there will be enough jobs for everybody? That's a big question mark.

**Philip** [00:20:57] Interesting. Lenny, if you have a question go ahead.

**Lennard** [00:21:01] Yeah. I've just learned the question regarding the jobloss, because if I think about Germany, for example, like the GDP is actually made of big concerns, like now big automotive companies like Volkswagen or Mercedes. So do you think that they are able to make the shift towards sustainable mobility in five years time? Because for the last 20 years they were focused on like the original engines.

**E6** [00:21:34] That already putting great strides towards it. But it is hard, especially legacy companies. You know, that's why Tesla has been beating a lot of these companies. But of course China is behind them. China can deploy very quickly and they are not as concerned about environmental issues, even though they are changing. And also the concept of circular economy is very much implemented in China. It's actually very interesting to see what they have put into place. So I think, you know, all car companies are moving towards that. You actually see like all car companies are going to EVs but the thing is, they're trying to flood the market while resources are dwindling. So I think that the newness, the innovation needs to be retrofitting. I think that's something we haven't discussed enough. The thing is, we're looking at resources in a very linear way in from of, let's see what we have here right now, instead of an innovative way. There's a website and research called Circularity Gap, and it actually looks at how much of the global economy is moving towards circular economy in the last couple of years has been 8.9% of the world's economy. So we got a long way to go. Let's look at how many billions of cars with combustion engines are out there in the world right now. How much retrofit can we take out of there? There is all this metal and plastic to be reused and we should really have industries to create economic development. And a lot of the car companies are doing that. I know that, like some of the German companies are definitely leading the way on new circular cars. The world economic forum has actually looked at I think it was with Mckinsey, because that's one of the partner, into the circularity of cars. And actually what is the index of implementing circular economy into the car manufacturing systems?

**Lennard** [00:24:06] Thanks.

**Philip** [00:24:09] Okay. Yeah, I think that was it from our side. Those were our questions. Uh, thank you very much for your time.

**E6** [00:24:17] Hopefully this was helpful.

**Philip** [00:24:18] Super insightful. Really, really interesting. Yeah, a lot of things I didn't see in my research as well, especially the increase in cars. Do you actually think that this would also be applicable for Europe, or do you think it's connected to the American culture?

**E6** [00:24:39] So, America is a very car centered culture which is so problematic. And, you know, like I was just in the UK and I just enjoying being on the train. Um, so I think there is a change in awareness int the EU, which is so much faster, which is great. I would say focus on last mile on like especially rural areas don't focus on cars first as this is the mistake the Americans made. Yeah you know like really kind of compare what's happening here versus there and I live in a city that's like better with public transportation, but it's not that great. And even though I have a car, I have a parking spot here, I do use a lot of shared mobility because I don't want to park. So. So there is also that kind of, you know, people's personal behaviors. Um there is a very definite centralization around cars in America. And it also city wise it depends. New York it is very, very much about public transportation and shared mobility in San Francisco as well. L.A. less and for people in the rural areas it is essential to have a car.

**Philip** [00:26:05] Thank you very much for your time. I think it really, really helped us. Thank you very much. And we can also send you a copy if we're done with the work. Then you can also go over it. We're planning on being ready in the middle of May.

**E6** [00:26:19] Great. Oh, well, almost there. Well, well, good luck and lovely to meet you

***Transcript Interviewee E7***

***--- Start of recording ---***

**Philip** [00:00:01] All right. Then I'll start the recording now and I'll start with the first question. This relates to the social pillar and we have defined the indicator of accessibility, and we have defined it in such a way that we are primarily concerned with ensuring that rural areas are better connected to the mobility infrastructure and that all of this is offered at a fair price. So maybe you could just give a brief assessment of how you think our concepts could contribute to that?

**E7** [00:00:31] The problem concerns, I think, not only rural areas but also urban areas. In principle, each city and region has its own app. There are two main problems here. The first is that you would need 50 apps when traveling through Germany. There is no super app in that sense. In Switzerland, we have the Swp app, but it also doesn't have everything. In Zurich, there are nine mobility apps and none of them is comprehensive, so to speak. That's already a problem of access from the point of view of the software side or the information side. And the other side is of course then always the concern if the hardware is actually available, is the scooter really at its location, is it in a good condition and is it also loaded up. And so on and so forth. And how far do I have to walk from the platform, with the suitcase and all these stories and that is of course already really massive challenges for the whole topic of smart mobility. Because the alternative is always to have a car, I throw my stuff in and I know exactly what the process is. This hardware availability is of course even more serious. Then there is the economic aspect, which you mentioned, regarding the price. I think autonomous driving could bring a great opportunity, because then you can simply cut the personnel costs. When it comes to the "Ruf buses" or "Ruf cabs" the main driver there are simply the personnel costs and there could be an opportunity with these autonomous vehicles that the rural areas can be better connected. But

we would need a super app from my point of view for Germany and maybe even for Europe as it also exists in Asia already.

**Lennard** [00:02:31] Maybe a quick question about that in terms of availability, accessibility there is still criticism that electric mobility and also hydrogen propulsion is too expensive. Do you think that this could change in the next few years and that this will also make it more accessible for other people?

**E7** [00:03:03] So the decision has now been made for battery electric, at least everything that concerns passenger cars and minibuses and so on. The automotive industry is now converting its entire production, including battery plants. So hydrogen and synthetic fuels are completely out of the race in my view. First of all for the next 50 years due to the conversion of production capacity, which has already taken place and is now in full swing and therefore the decision was made, so to speak. And hydrogen at best for trucks and buses. And e-fuels in the marginal area of classic cars, motor sports and aircraft, because batteries are simply too heavy for aircraft. But I think the decisions have actually been made a long time ago. And then, of course, there will also be economies of scale in the next few years. Batteries will certainly become cheaper and more environmentally friendly, but there are also massive economies of scale now that the entire industry is investing in them. So I'm hopeful for the price to reduce, and we'll have to see about the production of the electricity. There are people who say that the solar industry will gain massively now by turning to electricity as a driver. This will result in massive improvements. Maybe someday even electricity costs at zero if you can have solar panels to achieve a basic charge in the car.

**Lennard** [00:04:51] And very briefly, when you say the decision for electromobility has already been made, who made it?

**E7** [00:04:57] So politics has made the decision now. EU with the decision to ban internal combustion engines from 2035, but before that it has long been met on the manufacturer side. Many car manufacturers have long ago announced the exit. For example, Audi towards on 2028, only BMW is the only German company that somehow still believes in the internal combustion engine, but all others decided since a long time that the phasing out of the internal combustion engine takes place. Of course, this was especially driven by China because the Chinese market converts completely to E-mobility. Clearly because that is the only area where they have a chance to compete as with the internal combustion engine they do not have a chance. And now Germany is under massive pressure. Because of the size of the market.

**Lennard** [00:05:48] But the exit from the combustion only relies on e-mobility then because you just excluded hydrogen from more or less as an alternative?

**E7** [00:05:57] Yes, I'm not saying hydrogen is bad. I'm just saying the industry has now made up its mind. Whether it is the better alternative, I don't know. But if you look now or if you look in history the automotive industry never pursued more than one technology. There has never been a time when two technologies were pursued in parallel over a longer period of time, and the decision has now been made, which is why many people were so eagerly awaiting it, and then VW fully committed itself to as the market leader to e-mobility. A conversion of the production facilities is taking place, as you can see everywhere now, and above all even battery plants are now being built in Europe, which means that billions are being invested. You can't reverse that within ten years. That is why the decision has been made.

**Lennard** [00:06:54] Alright! Thank you very much.

**Philip** [00:07:02] The next indicator would be safety. And here we were primarily concerned with safety on the roads, but also with the safety of employees, especially in relation to smart mobility with all the data that can be collected including accident detection. Perhaps you could give us a brief assessment of the impact you think this could have?

**E7** [00:07:23] Yes, basically it is the case that something like between 90 and 95% of accidents are human error. And I once read a figure in the USA. More people are killed every year because drivers spill hot coffee than on 9/11. So we all think we can drive, but basically people have to go. You can see it. There was a number from the NHTSA that said that all the driver assistance systems in the U.S. have saved 400,000 lives over time. So every level of automation brings more safety, even if we don't believe it. But fact it is simply getting better in terms of traffic accidents. After all, we still have 1.2 million deaths a year 50,000,000 injuries. Gigantic numbers. Of course, they won't go down for a while, because these victims are mainly in Africa, South America and Asia, and this technology won't arrive there as quickly. But here we have falling numbers and that has something to do with the driver assistance systems. That's one point where I believe that safety will increase if you increase automation. The other one is with the data as an example the navigation systems we can delete the targets we put in, but these are far from being completely deleted. In the meantime, we even have the possibility to identify diseases in the steering behavior. Recently, there was a project at the ETH Zurich that, for example, can identify depression or diabetes from driving behavior. It's incredible the amount of data that is apparently being collected. And up to now, it's been with the manufacturers. I think that's the crucial point when you get into the world of autonomous driving. Who actually has access? And who hosts this data? And it's easy to imagine a neutral third party with access

for everyone. Insurance companies want access to it, traffic authorities, the manufacturers, the car dealers, everyone wants access. But I think one solution, and I know that it has already been discussed in the Bundestag, would be for this data to go automatically to a neutral platform. And then everyone would be entitled to some part of this data, so to speak. Health insurance companies also want to have access to it, because they know that we can identify drunk driving and driving behavior. And so on and so forth. So that's still open. But I can imagine such a solution.

**Philip** [00:10:23] Exciting. Lenny, do you want to take another quick look at your topic?

**Lennard** [00:10:30] Perhaps only very briefly a point to this, because I heard a lot of electric vehicle always criticized because of the security. Because there was this one video where many were shocked where a Tesla burst into flames and the battery was not extinguishable. Especially in accidents, how do you assess the safety risk?

**E7** [00:10:56] I can't really say now, but I would be relatively relaxed about it. Look, we now have 140 years of development of internal combustion engines and how many years of serious development put into e-mobility. No more than 5-6 years. And we're still going to make gigantic progress. I would be relatively relaxed about that. And the whole discussion about these raw materials that go into it, mining by children's hands in Africa and so on. Oliver Blume once told me, head of Volkswagen, at that time he was still head of Porsche, that in a few years it will no longer be an issue, there are materials in there that are completely unproblematic, that can be recycled up to 99%. And you can imagine that once the research group gets to grips with it, a lot will happen. And I mean with regard to Tesla, they now also have autonomous driving only with a camera. No one else is doing that in this form. So it's just Elon Musk and he's pushing

ahead and then something happens. But I don't think it's hurting him at all. Quite the opposite. You get the impression that it gives him that touch of I'm just daring something and taking a risk.

**Lennard** [00:12:19] What you have briefly mentioned, the mining, which then takes place partly really still in the Congo under the partly by human undignified conditions you see there an improvement in sight, or?

**E7** [00:12:41] Unfortunately, I have no first-hand experience in this subject. I don't know exactly, but I can well imagine it. And just think how many billions the automotive industry invests worldwide in combustion engines, if the money really goes one-to-one into electromobility then we will also achieve an improvement there.

**Lennard** [00:13:22] That is a good point.

**Philip** [00:13:28] The next pillar would be the environmental pillar. The first indicator we looked at was decarbonization. And under that we looked primarily at the reduction of greenhouse gas emissions, but also at the implementation of renewable energies. And perhaps you could also give your assessment of how you think the effects would be on Smart Mobility?

**E7** [00:13:53] Yes, well, e-mobility is separate for now. So if you were to do smart mobility with combustion enigne - which there is - then the two big changes would be autonomous driving and connectivity. There are simulations that show how many millions of tons of fuel we could save if, for example, if the infrastructure were connected to the vehicle. You drive up to a traffic light and the light signals the vehicle to switch to red in ten seconds. Then you could

put the vehicle on such a sliding pass, which then rolls very slowly towards the traffic light, and when it is there, it switches to green and you can then accelerate gently again. So we drivers, we just drive a lot to stop and go, too hilly or whatever you want to call it. And there's an incredible amount of smoothness that you can bring to that process. That's going to make an enormous amount of difference, an enormous amount. That would be the issue of connectivity between vehicles. When you drive in a convoy like that, you accelerate, brake, accelerate, brake. So car-to-car communication, car-to-infrastructure communication, so in terms of emissions and of course autonomous driving. The fact that the machine controls the braking and acceleration process with the knowledge of what is happening in front - these are two serious effects. There are some figures. I don't know how reliable they are, but they talk about up to 30% reduction in energy, so whether it's gasoline or electricity doesn't matter - we're also talking about a reduction in emissions.

**Lennard** [00:15:55] And maybe one last assessment, of the three types of propulsion that we mentioned, e-mobility, hydrogen or also biogas, which one do you think is the most sustainable or the most environmentally friendly?

**E7** [00:16:08] The crucial point is always where does the electricity come from? I mean, ideally, of course, hydrogen, but then green hydrogen. That is, if you could use solar power and produce hydrogen or all these synthetic fuels with solar power, then that would be great. The crucial point is actually, where does the electricity come from? And I read that the Chinese are building huge coal-fired power plants because they have so much electricity demand. That is of course not the point, then we have gained nothing. That's why the crucial point is where does the electricity come from? And there are two solutions, I think. One is to equip the houses with panels as far as possible, as well as industrial buildings and so on, so that you can really supply

the batteries with green electricity and solar power. And the other thing would be, if they want to have hydrogen and synthetic fuels, that they either produce in the Sahara, which would theoretically work because synthetic fuels are easy to transport, with hydrogen it would be rather difficult, because the compression is such a problem. Or what Porsche is doing , they are going to South America, where there is a lot of wind power, and building a production facility there for synthetic fuels. And it can then be transported well by ship, because this type of energy can be compressed very well.

**Philip** [00:17:47] Yes, and for the next indicator we want to look at the supply chain and have referred to the circular economy. And by that we mean, above all, that we use a lot of reusable materials, but also try to increase the shelf life of products. And perhaps you could also give us a brief assessment of this?

**E7** [00:18:10] Well, that's not really my topic. I know that there are a lot of circular economy efforts in Germany now, keyword if you google it Circular Repulic is a big initiative at the TU Munich, BMW and many others are also involved. But I can't tell you now exactly what Smart Mobility will bring. This mainly concerns vehicle construction. The only effect would be that you would need fewer vehicles, you would no longer have ownership, but shared ownership. And the car can be permanently in use and fewer vehicles are needed. I can well imagine that. And in the meantime, of course, it also has a geostrategic significance that this circular economy is needed to ensure independence from certain countries, because we have simply learned from the Ucraine how dramatic it is when cable harnesses are no longer supplied due to a state of war. But I can't give you a figure now of how much it could bring. You'll have to take a look at the homepage.

**Philip** [00:19:30] All right, we'll be happy to take a look. For the last pillar, we wanted to look at the economic side. We had selected the GDP indicator and were primarily interested in the cost reductions that can be achieved in supply chains, but also in terms of future crises, so that we can position ourselves a bit more crisis-proof. Perhaps you could also briefly give us an assessment of this?

**E7** [00:20:05] Access and perception about fewer vehicles again could have an effect and so of course low dependence on raw materials with a combination with Circular Economy. That's what comes to mind. On the other hand, there is of course always a downside. Of course, there is now a supplier industry, to a certain extent, and of course jobs and prosperity depend on it. Developing countries, for example. If you start cutting all that off, then you have a whole new set of problems. Despite all the skepticism about this globalization, which is certainly possible, it does of course have a shifting effect on prosperity. If cables are built in the Ukraine, then that was also a way of securing jobs in the Ukraine. And if one cuts all this relationship, if everything is recycled. Then jobs fall away there, prosperity falls away, national income.

**Philip** [00:21:33] And in terms of jobs, if you were to maybe analyze that on balance, would you say that more jobs will be created or more jobs will be lost?

**E7** [00:21:43] So in the short term, jobs will be lost. We can already see that in the automotive supplier sector, because this new electromobility is much less complex than the combustion engine. There is always talk of 10 times fewer parts. Then there is the fact that the battery, which is so to speak central, has so far come from Asia. This means that a considerable part of the value added, which used to relate to the engine and the transmission, is now a completely imported product. This means that the jobs are not in Germany but in Asia, in South Korea and

China. That could get better when our battery plants are up and running and we use batteries from our own production. So in the short term I think it will not be easy in the long term new jobs can be created. Other types of jobs, however, are of course also a transformation process - new skills, new virtues, on the employee side. But I believe that this change will initially lead to what is known as structural unemployment.

**Lennard** [00:22:55] Perhaps one last question on this. You have already mentioned that China is somewhat ahead of us, especially with regard to batteries. Is that perhaps also a threat to large companies in Germany such as VW, Volkswagen, BMW and Mercedes Benz?

**E7** [00:23:10] So the battery is certainly the key technology in the new vehicle. I mean, everything else is construction kit. So building an e-motor is not really witchcraft, basically anyone can do it. But the art actually lies in the battery. It has to do with the amount of energy you can get into it, but also the range. What is the best way to squeeze these battery cells, so to speak? These are all things that have to do with software. The real core of the electric vehicle is the battery. And that's where we have massive disadvantages now, of course. I don't know exactly whether it will be so easy to make up for that, but it seems that we will. We waited a long time to switch to this technology.

**Lennard** [00:24:12] Thank you for the assessment!

**Philip** [00:24:14] Yes, thank you very much. I think that's it from our side. Thank you for your time and all the valuable information!

**E7** [00:24:28] All right thank you too and good luck with the work!

***Transcript Interviewee E8***

***--- Start of recording ---***

**Philip** [00:00:00] Then I would start the recording right now. You are welcome to give us a general insight into the topic from your side.

**E8** [00:00:11] So in the past, transportation was very product based. You had to buy a car to be on the road. The development to Maas would mean that you first pay a subscription model and then have access maybe to a rental scooter to a rental car, the local transport system. In other words, you would have a transport subscription that includes the various modes. Shared mobility is also very important for that, be it ride sharing, like Uber or Bolt or autonomous driving. But usually it's expected that these vehicles will also have alternative propulsion technology. So for micro mobility it's just like, all the rental scooters are electric. The reason with other sharing models is that alternative propulsion systems are more expensive than conventional ones. However, the initial cost is higher than the true energy cost, so the fuel cost is lower. So it's more expensive to buy an electric car, but once you buy it, electricity is cheaper than filling it up with fuel. So that will make shared vehicles, so whether it's a cab or an Uber or at some point an autonomous vehicle. Those will definitely be electrified first. You're seeing that more and more in many cities now, for example in Paris most Ubers are electric now. There are people working on autonomous vehicles that will definitely be electric as well. That's why, at first glance, it wasn't so obvious to me to separate the two. I think the two go together. The first reaction to the alternative propulsion technologies is that there are different propulsion technologies that are available. So electric mobility has the highest market share right now. Either as a plug-in hybrid or as a fully electric. There are also hydrogen vehicles. But these are less relevant for passenger car traffic, if at all for heavy vehicles, i.e. trucks over long distances.

There has been a bit of a technology race in five years, especially between European manufacturers and Japanese manufacturers. So Japan has been very strong on hydrogen, so with Toyota. While the Europeans in Volkswagen have rather put electric cars, but it is now becoming apparent that it is electric vehicles that are making the race. The reason is that hydrogen vehicles are first of all much less developed. So many vehicles are ready for the market, are already being sold. I think there are only one or two models are very expensive. They are only available in small pilot projects, i.e. some cab companies that have purchased a few with a lot of subsidies. And if you look at the long term, the big difference between the two is that the e-cars are much more energy efficient. When you refuel an e-car you can produce the electricity through wind or photovoltaic and charge the battery immediately. You have a small energy loss of less than 10%, but you can also use the same electricity and make hydrogen with electrolysis (electrolyse). Then you have to get the hydrogen into the car, the problem is that at the moment there is no hydrogen infrastructure. So it would have to build all the gas stations first and then you would use the hydrogen in the fuel cell car to convert it back into electricity. That means in the end both are electric cars. The only difference is that with hydrogen you have several additional conversion steps where you always lose energy. So there is a certain consensus that hydrogen will probably not be relevant for cars, maybe for trucks, but only in some regions ITF recently published a report to compare for trucks in Europe. And it came out that electric trucks will be the cheapest. Hydrogen will be used mainly for aviation and shipping. Aviation cannot be electrified. There it would be more relevant to use hydrogen. Concerning natural gas for cars, even the lobbyists from the climate perspective now admit that it makes little sense, it is more efficient than gasoline in combustion, but in combustion less direct CO2 emissions. But you have many upstream emission sources. Natural gas production produces gas that escapes, so the climate benefit you realize from burning is already gone. That's why nobody really talks about natural gas in cars anymore, when it was very pushed ten 15 years ago also a

lot by Italian car manufacturers. Italy had a lot of interest in natural gas because they have a lot of energy companies that are out in North Africa. And it was heavily promoted for different vehicles, so first for cars, then more for trucks, for ships. But I think it's also more of a consensus that it doesn't necessarily have much to do in the transportation sector, especially for cars. And it's similar with biogas. In the long term, I think it will be more interesting for aviation. You can make biofuel from biogas. That was exactly my first impression of your research scope. As a little background. And otherwise, we can go through the questions now.

**Philip** [00:08:39] Very very exciting. Shall I start right away with the first question? With our first indicator? That would be accessibility. And by that we mean that rural areas are better connected to the mobility infrastructure and that mobility in general becomes more cost-effective. And maybe you can give an assessment of how these concepts could contribute to that. So also like if you think that both are very connected, both in combination with each other.

**E8** [00:09:15] So I think the concept of smart mobility is probably more relevant. Well, public transport is better for the environment because it's more energy efficient. It should always be the first choice, for example in cities. Someone who takes a bus to work in the city causes less environmental damage than someone who drives an electric car to work. Is it different in the countryside? It's difficult to provide public transportation in rural areas because the utilization is not really high enough to be efficient. So it's usually heavily subsidized. And this is where new mobility concepts can perhaps help. I come from the village and the bus to the next town comes once an hour every two hours often there are only 5 people sitting inside. A change that would be possible with new technology is that public transport reacts more to demand. So that only a bus comes when there are really passengers. It can increase efficiency, maybe bring down costs because you can better control the vehicle size. You don't have to operate an unnecessarily

large bus on a route where there is actually less demand. And you could also make the transport service more flexible, more based on demand. If someone wants to get from A to B, the person doesn't have to wait two hours. Then alternative form of propulsion also plays a role. One thing that came to my mind is that for electric cars, charging infrastructure is very important and it is strongly concentrated at cities, is partly not available in the countryside. Whereas it's also the case that in most countries anyway it's mainly buildings charging stations, not public charging stations that are needed. Exactly. It's difficult to give a general answer, but there are just two points that come to my mind.

**Philip** [00:12:11] Yes, these were very exciting insights. Then I would go straight to the next indicator and that would be safety. And there we looked at safety on the roads, but also the safety of employees in supply chains. And maybe you can briefly go into how you think these two concepts could have an influence on that.

**E8** [00:12:40] I think I see it separately, honestly. So autonomous vehicles are potentially safer than human drivers. Alternative drive technologies don't really have an impact on safety. A car is not safer or more unsafe if it's electric or gasoline powered. You could define safety a bit more broadly and also consider health impacts. Alternative propulsion technologies have the advantage that they cause less air pollution. Right. But other than that, I see direct links between the two.

**Philip** [00:13:36] And do you also see a risk with smart mobility in terms of cybersecurity, or do you think that won't be as relevant?

**E8** [00:13:46] Yes, it's definitely relevant. But I don't see it as a major problem. Yes, I'm sure the manufacturer is keeping an eye on it, but I wouldn't say it's one of the main threats.

**Philip** [00:14:13] Okay, and then I would move on to the next pillar. That was the environmental pillar and there we looked at decarbonization. And there we were mainly concerned with reducing greenhouse gas emissions, but also increasing the use of renewable energy, and maybe again a quick assessment from you on how the concepts could contribute to that.

**E8** [00:14:36] The point is more relevant than the previous ones. So both concepts have a strong influence on the emission balance of transportation. I have already given an assessment of the different technologies. So electric cars are already more efficient than combustion cars in all European countries, for example carbon. Even in countries with a relatively high share of coal-fired electricity. It is expected in the next decades that the number of renewables in the energy mix will increase. This will further improve the efficiency, the carbon efficiency of electric cars. So much for powertrain technology. And also Smart Mobility has the potential to get people out of their cars and into public transport, reducing emissions. There are three pillars in the transportation policy: avoid, shift and improve. Avoid means that you first reduce transportation activity, for example by meeting on Zoom instead of flying to a meeting. Shift means shifting activity from energy-intensive to more efficient means of transportation. For example, from air to rail or from car to metro. And improve means improving vehicle technology or improving fuel technology. For example, switching from a combustion car to an electric car. And smart mobility would make a good contribution in that it would make it possible to increase the share of public transport in the transport mix. Because it would become more user-friendly.

**Lennard** [00:17:02] A very quick question. I've also read that electromobility is always viewed a bit critically, of course, also because of the degradation of the batteries. How do you see that?

**E8** [00:17:21] There is the concept of life cycle assessment. This considers all environmental impacts of a product from production, use to disposal. With a combustion car, most of the environmental impact is caused during use by burning gasoline. With electric cars it is the same at the moment, because electricity also causes emissions. But it is the case that the production of e-cars is more environmentally intensive than the production of combustion cars. But the higher environmental impact is still offset by the fact that the cars produce fewer emissions during their use. So it's true that there are problems and also potential for improvement. But it's a bad argument to make a blanket statement that e-mobility doesn't make sense environmentally.

**Philip** [00:18:41] Exactly. And the next indicator we had was the concept of the circular economy, i.e. how this could be implemented in the production chains. And in the case of smart mobility, for example, a lot depends on all the data that can be collected and that can be used to make the production process even more efficient. And perhaps here, too, a brief assessment from your side.

**E8** [00:19:05] Ok. I don't see that direct connection. So what comes to my mind is that for electric cars it's very important to recycle battery materials. And manufacturers are doing it more and more now. So Volkswagen for example invested in a battery recycling plant even in the first generation of eCars, it was so that the manufacturers didn't really think about what happens at the end of life of the vehicle. Now it comes more on the one hand because of laws, on the other hand because battery materials are expensive. That means the car manufacturers have an interest in getting the materials back when the car goes out of circulation. There is also

the aspect of exports of used vehicles. So normally a car that is sold in Western Europe might first be re-registered in Germany, after a few years it might go to Poland and then to Romania, and at some point perhaps to West Africa. In many countries that do not have efficient rules, there are import restrictions on how old a car can be. This is because these countries have a very high proportion of old, inefficient cars. This is also relevant because e-cars are now coming into the system in the rich countries, which would then also end up in developing countries after a while. Then the question here is whether it is a good development or not. It can be a good development because the countries then get newer technologies that may not be available in the regular market. But it can also be a bad development if nobody really cares about the final recycling when the cars are no longer usable. I would say that it is a gut feeling that Circular economy is more important for eCars than for conventional cars because of the battery materials. There is also the aspect of smart mobility but less related to cars, more to micro mobility. That for example the scooters are sold as sustainable. But there are statistics that in some cities after a month end up on the garbage because the wear is so high.

**Lennard** [00:22:18] Concering the topics of scooter especially Paris was in the news due to their decision against electric scooters in their vote. Can you maybe also say a sentence about the recycling of hydrogen engines or fuel cells?

**E8** [00:22:33] There is less material involved, so a vehicle battery is just a lot of material. A hydrogen engine is smaller so it also uses more expensive elements but it is less relevant. I think it's simply because of the size of the hydrogen engine and the fact that there are so few hydrogen vehicles around that the absolute amount is not that relevant anyway.

**Philip** [00:23:19] Exactly. I would have continued with the last item now, too. That would be the Economic Pillar. And there we looked once at GDP and new job creation. What economic impact can these two concepts have? And in the end, a short evaluation whether more jobs will be created or rather lost by the implementation of these two concepts?

**E8** [00:23:46] So in smart mobility, especially autonomous driving. The first autonomous vehicle in my opinion will either be a truck or Uber. Of course, that will replace drivers, so in that sense it's a job killer for now. On the other hand, it's also the case that there are too few drivers. There is the International Road Union or Road Transport Union and they complain about a driver shortage. I think it was recently in the media in Germany that most truck drivers are coming from abroad and the trucking companies are having problems finding drivers. That means it's a question now, is it a job killer or is it something that makes up for the labor shortage? Can you look at it in a way related to the point of Smart Mobility? I'm not aware that there's been a lot of talk about it yet. I haven't read about concerns being raised. Yeah, what happens to all the drivers? It's not that on the radar right now. It's more hopeful that it can fill the labor shortage. In terms of the new propulsion technologies, the fact is that there are already changes in the industry. So, for example, the German car industry, but especially the supplier industry is very focused on the combustion engine. An electric car is completely different from a combustion engine. So the only thing they have in common is that they have four wheels and seats. And everything under the hood is completely different. And it is said that the production of electric cars needs less labor than the production of combustion cars. That means it may well have an impact. There may also be a change in some ways in the global structure. At the moment, the biggest car manufacturers are Volkswagen and Toyota. Toyota is a bit behind in e-mobility. Volkswagen is starting now, but it's still behind if you look at other manufacturers. This means that jobs may shift a bit from countries that are very specialized in combustion

vehicles to countries that are more specialized in e-cars, for example to China. There are now also policy approaches that actively counteract this. One example is the American Inflation Reduction Act. It's a subsidy program for various technologies that are relevant to decarbonization. They are now giving large subsidies, for example, for electric cars in the U.S., but with the condition that they are made in the U.S. and not elsewhere. That's a change because for example mainly especially batteries are made in Asia, so the big battery manufacturers are Chinese, Japanese and Korean. And now there seems to be such a trend perhaps for countries to actively try to keep jobs in their countries or rather to promote them. What will be seen? The European Commission is currently countering this trend a bit with its own package. And there is also discord because, for example, American companies are not exempt from European subsidy programs. But now there's an American program that excludes European companies. On the general impact on industry and on labor demand, I think there's a section in the report that I sent you in the email.

**Philip** [00:28:37] Yes. All right. Lenny do you have another question?

**Lennard** [00:28:44] Yes, perhaps just a very brief question on this, you just mentioned the German companies, such as Volkswagen. They also account for a large share of the gross domestic product in Germany. Can it be that a large company like Volkswagen disappearing has an impact on the entire GDP?

**E8** [00:29:16] Hard to say. So of course everything has an effect somehow. It's just a question of the extent. There are some German manufacturers who have slept through electromobility a bit. And yes, it's a risk. There may simply be a big shift in the market toward e-mobility, and

companies that don't have a corresponding product range may look a bit foolish. In other words, it is definitely a risk.

**Philip** [00:30:32] Yes, perfect. Then I think that was everything from our side. From our questions, too. And thank you for all the exciting insights. And that you took the time, it was really interesting. And yes, we'll be happy to send you a copy when our work is done.

**E8** [00:31:00] Super thanks to you too and if you have any other questions, you are always welcome to contact me.

***Transcript Interviewee E9***

***--- Start of recording ---***

**Philip** [00:00:00] Thank you. And then I would start recording now and start right away with the first question. And that would be the social pillar. And the first indicator we had chosen was accessibility. Our main concern here is that rural areas are better connected to the mobility infrastructure, but at the same time the services can be offered at a lower cost. And maybe you can just give us a brief assessment of how you think the two concepts can contribute to this.

**E9** [00:00:30] The first concept definitely contributes to this. Decentralized small buses, for example, which may even be autonomous and thus cheaper in the long term because they no longer need a driver. Drivers are a large part of the costs, especially for cabs, but even more so for buses. This means that you could really drive smaller units, more small vehicles, which then come to smaller villages, perhaps even on-demand and not only according to a cycle. So for me, that is clearly the higher impact. With alternative fuels, they tend to be more expensive, and the infrastructure is often not worth it, and it tends not to be cheaper. And whether they're talking about hydrogen, it's still relatively expensive. Alternative fuels are also relatively expensive. Only last year, the electricity became extremely expensive and therefore both on the Opex as well as the Capex side the alternative propulsions are firstly more expensive. And therefore that would rather not contribute to the social accessibility, also not to the geographic. Because if the infrastructure has to be distributed in rural areas, it will be even more expensive per vehicle because there are far fewer users. So of course you can make everything super smart, but then it might not be that much more expensive, but it tends to be more expensive.

**Philip** [00:02:16] Yes, and when you say on demand, you are referring to the data, you then see from smart mobility, from connectivity, that you know where is the demand at all, where do we have to go at all?

**E9** [00:02:29] Exactly. So that would ultimately work like an Uber, only with a minibus, so then you would have an autonomous what I've seen ten-seater or a Sprinter or something like that it doesn't have to be a big bus, but especially in rural areas. The next advantage of this is that you can also create multimodality more easily. So I take my commuter train somewhere to the village, but I still live in a smaller village somewhere and then I can cover the last mile quite well.

**Philip** [00:03:50] And just a little question about that. Do you think that the Internet connection in rural areas could become a problem?

**E9** [00:03:59] In Germany, definitely. But I sometimes have no reception in Berlin Mitte, and that's with Telekom. That is often a problem, that the computers need relatively much data. So the Mercedes will now switch to the Google navigation. This is of course actually better than the other than the normal integration in the vehicle, not so dynamic or simply not so good. The problem is of course with Google maps you always need internet. There are also other vehicles that already have Google navigation that also drive with Android system in part and if then the Internet is gone somewhere in the Italian province then you find your hotel just no longer in the evening at 10. Yes, that is actually a problem.

**Philip** [00:05:06] All right, all right. Then I would go to the next indicator and that would be safety. And there we looked at road safety in particular. And maybe you can give your assessment of the two concepts, how the influence could be.

**E9** [00:05:32] Both have a very positive impact. Smart mobility, of course, has enormous potential. So that's probably even the bigger one, because accidents are simply avoided. That is, the autonomous vehicles from Waymo, but I mean, a lot of tesla and so on are doing that. Waymo has already collected millions of kilometers in the USA years ago without an accident. It's always such a publicity problem, when the computer drives you to death, it's somehow bad, because someone is to blame. So there's an ethical problem. How should the software decide? A car has to swerve, do I kill the grandma or the child? That's for the computer to decide. These are ethical problems that I don't know how to solve. But in principle, autonomous driving or perhaps assistance systems that warn me of the end of a traffic jam, automated braking, will prevent accidents or make them less serious. If something happens then, for example, the fire department is recognized as a road sign and you just crash into it like a few years ago with Tesla. Okay, that's stupid, but the bottom line is still fewer deaths and injuries. From there, that has very well influence. Now, with alternative drive technologies, you have to differentiate again. A few years ago, when there were only three Tesla models, they were the three safest cars on the market. And after that came all the others. And the advantage is that there is no engine block ramming into the passenger cell. This means that they have incredibly good passive safety in the event of an accident. They have a better crumple zone at the front, and what is a very, very big advantage, which all battery vehicles have, is that they have a much lower tendency to roll over, because they are incredibly, very, very heavy vehicles. Battery vehicles are really heavier than an internal combustion engine for the same size. And these batteries are very deep in the ground and therefore they don't roll over so easily. Well, they have

other problems like easier flammability, but in an accident they are often safer. But then the accident has already happened. In other words, smart mobility has the greatest impact because it can prevent an accident once it has happened, but an electric vehicle is relatively safe and, of course, nothing will change with alternative fuels for the time being.

**Lennard** [00:08:49] I have a very short question about this. I saw on Linkedin that you are also an expert in hydrogen. How would you assess the safety of the fuel cell?

**E9** [00:09:03] In principle, it's very good. I would almost have said that it has a somewhat lower tendency to burn than an electric vehicle. So it doesn't burn down that often. But in Norway, for example, there is now the first shipping company that no longer takes electric vehicles on board, for example because they still burn from time to time. And there was yes in the Mediterranean Sea a ferry with hundreds of Porsche torched and that was a huge damage. One vehicle burned down, they all caught fire. So, that means the batteries can start burning out of nowhere, so I would conclude that the fuel vehicle is a little bit safer. But there also has a battery of course, so that has such a power battery pack in the back mostly but much much smaller than probably the likelihood of the smaller battery starting to burn is less than if I have five times as many cells or ten times as many cells. And so that's a little bit safer. The fuel cell itself doesn't burn so nothing can actually happen. That are usually noble metals or a very expensive platinum built and one the carrier material can also burn one from plastic. But there I would worry less. And the tanks are of course what people are afraid of. And the tanks are actually safer than a gasoline vehicle, because gasoline or diesel is even more dangerous, it's really sticky, oily, greasy, and it drips down and burns under the car when it leaks out. And then the hydrogen, which is already gaseous, burns away on the side.

**Lennard** [00:10:54] By tanks, you mean fuel cell electric vehicles?

**E9** [00:11:01] Yes

**Lennard** [00:11:02] And for pure hydrogen vehicles?

**E9** [00:11:04] These are pure hydrogen vehicles. Fuel cell electric vehicles are fuel cell vehicles. There are other concepts, but what we are talking about now are hydrogen fuel cells and of course they also have this battery to buffer the power. But they only run on hydrogen and the hydrogen in passenger cars is usually gaseous.

**Lennard** [00:11:32] There are pure hydrogen vehicles or those that do not have a fuel cell at all, but a normal combustion engine.

**E9** [00:11:37] So if you now look at a pure hydrogen vehicle then I would delimit differently. An electric vehicle that runs on hydrogen and you can run an internal combustion engine on hydrogen, so two completely different concepts with the same fuel. The big advantage is, that is often overlooked by the hydrogen combustion engine is not only is very very very very much cheaper than a fuel cell. It also gets by with very poor hydrogen qualities, because it simply burns it. So if there's a little bit of sweat in it, it doesn't matter, and the fuel cell, it breaks down relatively quickly if there's not extremely pure hydrogen in it. And the fuel cell is really expensive, if it fails, you have a total loss. And they always tell the combustion engine hydrogen combustion engine too low efficiency needs too much hydrogen. Hydrogen is expensive, that's why the costs are so high. But they don't take into account that you can also get by with poorer quality. And high purity hydrogen is very expensive. ICE (internal combustion engine), the

combustion engine, is safer because it doesn't have this battery pack that can theoretically burn. But these are all things that happen once in a million, but they are all totally rare. But this battery just falls away with the internal combustion engine again and he has only the tank and every tank where explosive things somewhere a certain risk.

**Philip** [00:13:38] All right, then I would continue with the Environmental Pillar. And there we have looked at the issue of decarbonization, and by that we mean, so to speak, the reduction of greenhouse gas emissions, but also the increased use of one of the renewable energies. And maybe just again from you a short assessment on the two concepts.

**E9** [00:14:01] Okay, I have to say one little thing up front. Again, because we talked about decarbonization, I also noticed that when you talk about alternative drives and you write EV and bio liquids, the word decarbonization doesn't fit. So now we have to talk about defossilization, or perhaps more simply about greenhouse gas reduction. Well, that's a bit of splitting hairs, of course, but the fact is that decarbonization means CO2 emission reductions, and that usually means an electric vehicle that does not emit any CO2 during operation. A biofuel emits CO2 during operation, but this is climate neutral, to a large extent. So CO2 is produced during combustion, but it was previously taken from the atmosphere and from plants, and that's why it's not decarbonization, it's defossilization. And some people are always pushing this word, decarbonization. And that is actually totally dubious. We represent a technology of open climate protection, and decarbonization plays no role in that. That's actually a smokescreen from people who want to prevent individual mobility. But that was another topic. So when we talk about greenhouse gas reductions, both have great potential. Of course, if I drive a fossil-fuel combustion engine, and then I use Smart Mobility and I can find my parking space ten minutes faster, then I have a certain effect. Or maybe I can somehow float along a bit

easier with an autonomous vehicle and don't have to accelerate and brake as much, so I can save fuel. That is also totally valuable and should definitely be done. But that alone will not save it. Not even if the autonomous driverless bus consumes fossil energy. This energy will also be consumed again. So there is potential for savings, and it's great. Ultimately, however, the greenhouse gas reduction must come from the drive system. Yes, but that means that that's where we have the real leverage at the moment. And again, it depends on the situation, battery vehicles have advantages and disadvantages, just like all other drive systems. So with battery it is just the problem. Today, and probably for many, many years to come, at least in the foreseeable future, batteries will be manufactured using the enormous amount of energy that is usually generated by coal and not necessarily by coal-fired power or actually coal. This is a thermal process, the cells have to be dried, this is not even done in China with coal-fired power, but actual coal and that is even worse. That is, we have at the electric vehicle first of all a huge mountain of Emoissionen, which we generate, in the hope that we then, if we operate the vehicle with green electricity, then over the useful life then have positive effect at the end. bottom line and with greenhouse gas emissions save. Long term the vision is that the batteries are made completely green maybe osgar with green steel and then if those are also run green then the battery vehicle is potentially climimanuetral. that way, but depending on what kind of power is fueling that is not necessarily better. Efuel I can now theoretically make from renewable electricity is always a bit of a question where does the energy come from? But potentially, what is the greater imapct of the two columns? In any case, the drive, because the drive, whether it's a renewable battery vehicle or a vehicle with biofuels, hydrogen, that can make the vehicle climate-neutral, and of course a smart mobility can't do that.

**Philip** [00:18:35] And how do you see the potential with regard to ciruclar economy, that it can be incorporated into the production chains, so to speak, and thus also reduce greenhouse gas emissions?

**E9** [00:18:48] So I honestly thought that drives, unless it's biofuels or efuels. that is, as far as it's an electric vehicle, it actually makes it all worse. I have to get very difficult, expensive raw materials from somewhere and then when I make alloys or thin coatings from them. I steam a layer of platinum onto these extremely thin platinum layers. In the end, I have to take it apart again when the car breaks down after 20 years. And then I turn it into a new battery or a new fuel cell. So it's a huge effort. The alternative drive systems don't make it any easier, in fact they make it more difficult. Of course, we hope that we will be able to obtain raw materials from the circular economy, from recycling, which we can then use again. But you can't do without them anyway. I need enormous quantities. And I hope that in ten or 20 years we will have enough recycled material to cover part of the demand that I have. But the demand for raw material is so huge. So to see an advantage there now, that you have to recycle that in the end, that's a big burden. An internal combustion engine, it's made of aluminum, it's melted down.

**Lennard** [00:20:17] A very quick question. I've read that fuel cells are usually all about the platinum that needs to be recovered.

**E9** [00:20:28] Essentially. I'm not an absolute specialist when it comes to chemistry, but platinum is the essential material. I think there are also gold compounds in there. So there is gold, which is also often used industrially. You need materials that are resistant to external corrosion. And these are the precious metals. And essentially platinum.

**Lennard** [00:20:50] And maybe one last question, when you say e-fuels do you mean only the hydrogen powered vehicles or do you mean other alternatives?

**E9** [00:21:05] Yes, exactly. So there is the definition also, what is so in the newspaper. Everything is not quite scientific. I have taken the common definition of efuels in the sense of hydrocarbons, i.e. substitutes for existing vehicles, and that is what is commonly referred to as efuel, i.e. an electrically generated gasoline, diesel, but also of course methane. So we have these methane natural gas vehicles, so natural gas is methane and that is also a hydrocarbon CH4 and I can also produce it synthetically. If you look at it a bit more scientifically, then e-fuel would be everything that is electricity-based. That's why hydrogen, when you get right down to it, is also an efuel. The simplest, so to speak. Now when I say efuel, I mean gasoline diesel substitutes. But that's just because it's colloquially misused.

**Philip** [00:22:21] And as a last point, we wanted to look at the economic side and there we had chosen the BPI as an indicator, but perhaps also simply related to economic growth. What impact could these two concepts have?

**E9** [00:22:47] Yes, that is. That's a very, very difficult question. And it always depends on whose BIP. In terms of Chile, it's top. So what they're making a killing on ltihium. There jobs are built. Liquid fuels gemach the one from the very remote areas of Chile, where these plants are now just started to build, over the whole world can also there jobs are created, also there of course not only in Chile of course, so everywhere where mining is done, in my Congo, the warlords earn there also not at the whole cobalt. In China, the majority of battery cells are produced, which is enormously good for their GDP. In Namibia there are hydrogen projects, in Morocco also Australia is a very big profiteer, they produce the energy and also the raw materials as a

big mining country. Here in Europe, especially in Germany, in Portugal I know my way around, but we don't like to do mining Who of us wants to, who of the three of us gives it in the tunnels? We prefer to leave that to other people. In addition, of course, we have environmental regulations and so on. Mining in Germany is difficult. Sweden is also a mining nation that looks a bit different from the rest of the world, and they've now also found deposits of lithium. It will take another ten years to develop them. In other words, we are more confronted with the question of how many 100,000 jobs will be lost in Germany as a result of electromobility. It is said that electromobility has the great advantage that things no longer break down so easily. So when it breaks down, it's usually a total loss. But these normal wear parts, apart from the brakes, because the vehicles are so heavy, you need more brakes, so the tires wear out more quickly, but everything else there is no oil pump. In principle, it is so that such an electric car has hardly any maintenance costs or can be viuel less broken, so transmission damage. There are always exceptions. But all in all, with batteries you hardly have any maintenance costs. Even fuel cell vehicles, almost nothing breaks down. And that's good. But of course, all the jobs in the workshops are eliminated. The manufacturers of spare parts are left with nothing. For the manufacturers of exhaust systems stand before the nothing. In the transmission, manufacturers face nothing. All those who work in engine plants face nothing. And then the question is, if we import the battery cells from China and patch them together here, can we? Could we compensate for that? Probably not. There are various different scenario calculations or studies that say between 100 and 2,000 jobs will be lost out of 800,000, especially among suppliers. That is, of course, a real problem. We are now at Ford, where two or 3,000 people were laid off in the Saarland a few months ago, and now everything is starting to go, all the smaller companies, the smaller suppliers. That means that the job losses are now slowly starting. Whether we can compensate for this, for example by bringing battery cell production here, is very questionable. Because electricity costs are high in Germany. Therefore, it looks rather bad

for battery vehicles and good for hydrogen vehicles. It will be more in the truck area, because that is a bit more expensive also in terms of building the infrastructure. So the production of hydrogen is also not without effort. There it could go out on zero or times the alternative drives provide rather for the jobs are dismantled. GDP-wise. It is difficult to say. It also depends on how much of it I export, for example. We have a high export share. That's not going so badly at the moment. Some of the vehicles are actually selling quite well. In percentage terms, it's still not that much. But the export share of battery vehicles is also relatively high in Germany. That's a bit up in the air. We don't even know yet to what extent the combustion engine ban will really come in the EU, whether there will really be both systems. It is also always presented in such a negative light, because jobs will be lost. You can also turn it a bit positive. We have a huge shortage of skilled workers. We have fewer and fewer people, and it's actually quite good that we can produce the same number of cars with fewer people in Germany, because sooner or later we'll run out of skilled workers anyway. So that's not a disadvantage per se, if you have to repair less, but actually quite good. But then, of course, the business is no longer there. You can sit down with the ZdK and ask them. They are more the branches that represent the workshops and the factories, the car dealerships. With regard to smart mobility, I could imagine that it could have a slightly positive effect. But I mean, autonomous driving makes drivers more likely to be unemployed. But the same issue of shortage of skilled workers. Who wants to be a bus driver? They have posters everywhere: "Become a bus driver. In doubt, this is a job that not so many people want to do anyway, and then there will be fewer jobs. And then there will also be fewer meter maids, perhaps because the cars park themselves. So this first pillar probably does not have such a big impact.

**Philip** [00:30:31] When it comes to smart mobility, do you see European companies as having more of an advantage, or are there other countries that are pushing ahead a bit more?

**E9** [00:30:39] Yes, of course the Americans are way ahead because they can collect completely different data. But that's also happening here now. So we can see that the companies are trying to collect the data and make something out of it. And the suppliers are also complaining that the vehicle manufacturers are collecting the data and, for example, not only the suppliers, but also the operators of the vehicles. So yes, I think we are trying to keep up somehow. There's really no question of catching up, but of course they're always ahead of the game when it comes to this, because they're also quite relaxed about data protection.

**Philip** [00:32:09] All right, thank you very much for many exciting insights. And we also plan to be done with the work in a month. Can also send you a copy.

**E9** [00:32:28] Very gladly, very gladly and much success and see you soon!

***Transcript Interviewee E10***

***--- Start of recording ---***

**Philip** [00:00:01] Then we can just start briefly by introducing ourselves, maybe two sentences. I can also start with pleasure. I'm originally from Munich, I did my bachelor's degree in business administration in Vienna. I then went to Berlin for an internship. And then I did another internship in Vienna and now I'm doing a master's in management in Lisbon. With a focus on innovation and partnership.

**E10** [00:00:29] Yes, wonderful. And I think my background is probably not that different from yours. I also studied international management, with a focus on entrepreneurship in my master's degree. And exactly, I worked a lot in the automotive sector during my studies and then six years ago I switched to my current job, which is entrepreneurship. This is the largest start-up and innovation center in Europe, which now has 450 employees. And I've been working there for six years now in the department for mobility, which has about ten employees and deals with the development of a mobility ecosystem. This means that we bring together a wide variety of players in the field of mobility, i.e. start-ups, established companies, and municipalities, and also carry out projects with them in order to simply test certain things. And why are we doing this? Because we hold the hypothesis that it is not this one player that will shape sustainable solutions for future mobility, but that we can only do it together. And that's precisely why we bring together different people.

**Philip** [00:02:04] Let's talk briefly about our master's thesis. Perhaps I can summarize it briefly. We structured our master's thesis according to the three pillars of sustainable development, i.e. Social Environmental Economics. That's how I would structure the questions now, going

through each pillar once, so to speak. And we had picked out two indicators for each pillar, and we had also picked out the two concepts of smart mobility and alternative propulsions. And we always want to measure these on the basis of indicators. And under smart mobility we understand shared mobility, connectivity and autonomous driving. And in the case of alternative propulsion, we have looked at the technology of electric, mobility, hydrogen drive, but also natural liquid gas and biogas.

**Philip** [00:03:58] Okay, we might as well start with the first one. That would be the social. And the first step we looked at was accessibility and affordability. And by that we mean that rural areas in particular, which are currently not particularly well connected to the transport network, can be better integrated, but mobility in general can also be offered cost-effectively. And now we want to investigate how the two concepts of smart mobility and alternative drives can contribute to this.

**E10** [00:05:12] So what rural areas are actually already doing, or are doing more of, is that they rely very heavily on private transport, precisely because public transport is less available than in big cities. To what extent could technological developments help to change this picture, so that they have access to public transport?

**Philip** [00:05:51] Exactly. I can briefly summarize what we have found in the literature so far. For example, that in rural areas it is mainly people with reduced mobility who live and who often have problems driving a vehicle themselves or using public transport at all. And this whole concept of shared mobility or autonomous driving makes it possible for people to still be connected to this mobility infrastructure.

**E10** [00:06:20] Wouldn't that also mean that they get access to public transport? So let's assume that autonomous shuttle buses will be running in the future. They will be operated by someone, and that could be a public transport operator. But then we're talking about public transportation again. But that is actually no longer in your scope, is it?

**Philip** [00:06:53] The way it's described right now is definitely the case, because that would also be autonomous driving. So that would also be a possibility, but yes in any case. That will also fall under it, I think. Yes, but in the interview really also quite simply give your opinion in general, so also just philosophize a bit, how you think you could contribute to it.

**E10** [00:07:17] Yes, okay.

**Philip** [00:07:20] Exactly. And that would be the first question, so to speak, as to how you think that our two concepts of smart mobility and alternative forms of propulsion can contribute to improving accessibility and, at the same time, also the affordbaility of the mobility infrastructure.

**E10** [00:07:37] Yes, I'm just going on the basis of the current problem that we see in rural areas, namely that you have just said correctly that there is simply no connection to public transport. That's why for many people there's simply no alternative to driving. Today, of course, the car itself is still mostly a combustion engine. Of course, the so-called drive turnaround can create the advantage that e-motors can contribute to reducing pollutants, which is currently the most prominent example, I believe. But that's not the question right now. It's about the social aspect. I can't imagine at the moment to what extent new types of drive can make things more social. Especially if I buy a new e-car now. It is an insanely high upfront investment, socially

disadvantaged people will not have the opportunity, will not have access to such technologies. That's exactly what will happen when such technologies are even more established than they are now and are cheaper. In other words, more affordable for such income groups. In the area of smart mobility, I can certainly imagine that this will bring something, even for people in rural areas who are less well off. Again, this is based on the problem. Why is there no public transportation in many rural regions or, let's say, smaller communities? Because it's just insanely expensive. The public transport system is mostly needed during rush hour, i.e. peak hour in the morning and peak hour in the afternoon, and not at all in between. But of course the public transport operator has to make sure that you have a constantly high level of travel options, otherwise the concept simply doesn't work. And that's incredibly expensive if the capacity utilization is virtually non-existent throughout the day because no one travels by public transport because there are simply too few people in the country. And this is where on-demand mobility in particular can come in. This is also something that can already be seen in the municipalities, in Germany and in other European municipalities. That you can either book a Sprinter bus via an app or, in some places, you can even call it. And then you get mobility either to the next virtual stop or to your home. And that's a lot cheaper than using an old bus. And that's where I would see the keyword connectivity. That progress will definitely bring us forward, so that there are simply alternatives for socially disadvantaged people in public space. Last but not least, because sometimes it's not so much a question of doing away with the car itself in public spaces, but rather of doing away with the third car. And if you now consider how much a car actually costs per month. On average, it costs around €400 per month. So with small cars, you can save an incredible amount of money if you simply don't pay €400 per month and have on-demand mobility. So that's exactly what I see in any case. Autonomous driving. Of course, that will probably contribute to making it work even better. But I think that's still a long way off. The main thing is to be able to monetize it. I think that's also what your master's thesis

is about, looking at what I can monetize, what makes sense? When I started in my current role six years ago, it was said that by 2030, autonomous driving would definitely be widespread, and we've actually moved away from that again. I think it will take even longer than 2030.

**Philip** [00:13:28] Okay, and you're talking about fully autonomous driving then, right?

**E10** [00:13:33] So I'm really talking about fully autonomous driving on public roads. So of course we're going to see autonomous driving on private property like airports or big campuses right now. Sure. But that's not exactly what we're talking about here. It's about mobility that is publicly accessible to everyone.

**Philip** [00:14:06] And I would just like to follow up briefly, because I found the connectivity quite exciting. Do you think that all the data that can be collected through connectivity might make the service more efficient?

**E10** [00:14:22] More efficient. In what way?

**Philip** [00:14:23] That you can offer more capacity utilization and more targeted to demand, as you have already mentioned, so that you really only send a Sprinter past when there is really demand and this Sprinter is still full and you can avoid all these empty runs, so to speak.

**E10** [00:14:46] I think that, as always, this critical mass is needed. So maybe moya in Hamburg can tell you something. Exactly, they also did a study on this. How many people would you actually need in Hamburg for your business model to pay off? And you haven't reached this critical mass by a long shot. So that also shows a bit how long it might take in rural areas for it

to pay off completely on its own. Well, public transport has always been a classic subsidy business anyway. So it will probably be in an on-demand shuttle mode for quite a while. But until it pays for itself completely, more people have to be convinced that this is a reliable, comfortable, time-saving mobility method and say, hey, I'm doing without my car and that's kind of what I want to fall back on as a mobility method. My thinking is that connectivity doesn't play such a big role and could change that, but rather that you have to convince people that this is the one and only way to be mobile.

**Philip** [00:16:22] Very exciting point as well. Then I would go straight to the next indicator, where we looked at safety, i.e. safety on the roads. And maybe you could also briefly talk about smart mobility in particular, what influence you think the concept could have on this.

**E10** [00:16:38] Safety means fewer traffic fatalities.

**Philip** [00:16:42] Exactly. Safety on the road.

**E10** [00:16:49] So I also believe that autonomous driving will have a major influence on the fact that we will see fewer accidents. Simply because the technology will be so good in the future and will also be better than human action. That you simply have fewer accidents, fewer accidents then also means fewer opportunities for there to be serious injuries or traffic fatalities. At the moment, people in major European cities and metropolitan regions in particular are looking at the so-called Vision Zero, i.e. actually pursuing the goal of having zero serious injuries or traffic fatalities per year in road traffic. And here, I would say, technology is not necessarily seen as one of the first levers to be used; instead, the responsibility is very much on individual motorized transport. So the idea is that the fewer MEVs you have, the fewer serious

accidents you have. That is, you actually try to regulate them. You try to have less individual traffic by cars. Now that doesn't matter whether those are e-cars hydrogen cars or internal combustion cars. You can see that from the environmental zones that are being introduced. You can see that from the fact that road user charges are being introduced. Not everywhere, of course, but more thought is being given to this. Even in Munich, where the automotive industry is very strong. But it's already happening in Stockholm, for example, and it's already happening in London. And we can see it simply by the fact that more thought is being given - and this is now also an example - to setting up bicycle lanes in Munich, in other words simply granting other road users more rights than car drivers. By taking away parking spaces, by simply making driving less attractive. These are, of course, levers for a city. They are not levers from a technological point of view. But what I find very interesting about this, even if you look at it from an automotive perspective like you do, is that the market, the automotive players, are also thinking about reacting more to such trends and scenarios, for example by dealing with bicycle traffic themselves. I think the best example of this is Porsche, which is very much involved in bicycle manufacturing. They bought the e-drive manufacturer Fazua here in Ottobrunn this year or last year, I don't know. So they manufacture e-drives for bicycles. And then they have also taken over a bicycle manufacturer in Croatia and want to enter a whole new industry, because I think they see how this trend is developing. So I find that, I find that quite exciting. Of course, I'm very far away from this whole safety issue. Um, but it is somewhere then also everything is connected with each other again. In my opinion, I think safety has little to do with propulsion in this case. So it doesn't matter whether it's a combustion engine, electric or hydrogen. So I can't imagine how that can increase safety.

**Philip** [00:20:54] I would jump right to the next pillar also because of the time, aass I don't hold you up that long.

**E10** [00:21:01] It can also be a bit longer.

**Philip** [00:21:06] The next one would be in environmental pillar. And there we looked at how these two concepts can contribute to decarbonization. And we understood this above all the reduction of greenhouse gas emissions, but also the increased use of renewable energies. And maybe you can give us a brief assessment of the two concepts, how you think they could have an impact.

**E10** [00:21:36] So starting with propulsions. So how does that fit in with the reduction of CO2 emissions? So that's probably exactly the topic for the drive turnaround. In the case of e-vehicles, of course, this also applies to hydrogen vehicles, but that won't be anything new for you, that it only makes sense when you look at the complete cycle. So from which kilometer and which driven kilometer does the e-car or the hydrogen car become really green, if you look at it from the production to the end of life? And of course, beyond that, the hydrogen or the electricity that is refueled, how green it is. Of course, you have to look at that very closely. And I don't have the figures in my head right now. But of course there are various calculations that then say from how many 1000 kilometers then the e-car is better than a combustion engine. What it does in any case, if you have more e-cars in cities, is that the air becomes better. So the transport sector is simply one of the main emitters, especially in cities, which has been stagnating for many years in Germany. I don't know how it is in other European countries right now, but in Germany it's just really critical and the e-car can of course contribute massively to that. It's just a question of whether you want to look at it from a single-eyed perspective or whether you want to take into account the entire lifecycle of such a car. Exactly. Can the connectivity of smart mobility also contribute to the fact that we have generation two reduction?

Yes, definitely. I think smart mobility gives us all these possibilities that you already described in your preparation paper. Just the fact that I no longer have to own my own car, but that there are many alternatives. So I'm just using fewer resources. That's CO2 friendly? Yes. In addition, when I compare the way people took the subway ten years ago with the way they take the subway today, I think connectivity has made a big contribution. I can see in real time whether my subway is on time or not. Ten years ago, I'd go to the station and realize, okay, now I have to wait ten minutes while there's a disruption or something. So connectivity has made progress there, too. And in the meantime, of course, I can also use public transport, apps or other apps from other operators to access not only public transport services, but also micro mobility and scooters, car sharing, bikesharing and so on. And that also has something to do with integration and connectivity and contributes to the fact that more people switch from the car to other forms of mobility that are simply more CO2 friendly. And that's why my opinion is quite clear. Connectivity clearly contributes to reducing CO2.

**Philip** [00:25:39] And with regard to the whole smart traffic management, that is, when we talk about smart parking, smart traffic. I always find the concepts mega exciting, but I always ask myself, how far are we actually in reality with this right now? So do you have any insight into this? For example, in the city of Munich right now? Is that an issue at all right now?

**E10** [00:26:03] Do you have an example for me on Smart Traffic?

**Philip** [00:26:08] So exactly, I had looked there once the Smart Traffic light, durhc the one the whole stop and go so a bit can escape. That you can signal to the car that the traffic light is red, and by doing that you can reduce the speed and create a more efficient traffic low flow. Or smart

parking, so that you see that there is a free parking space and you can avoid all the laps that you make.

**E10** [00:26:45] I think it's absolutely feasible from a technical point of view, and I believe it already exists in many applications. But I don't think we see it as much in Germany, for example, because some of the data belongs to the municipalities. So what switches a traffic light from red to green now. That is only known, of course, by the city that operates that traffic light. That's where I come back to the point I didn't make before. It's not at all in the interest of very many municipalities to make driving more convenient. That means parking. But that also means getting from point A to point B fluidly because the traffic lights are just good. I actually want to make driving super unattractive. You just don't want them in this density and strength in a city anymore. The trend, you can see this in Hamburg in particular, is more towards offering something like what you said, i.e. concerns about better traffic flow, that you want to offer something like that to cyclists. I'm cycling along a street and my app shows that in five seconds the traffic light in front will change to green. So you actually think you want that. You want to make cycling more convenient so that even more people switch from cars, for example, to cycling. So that's more what I'm observing. But it has nothing to do with technical feasibility. I am absolutely convinced that it is possible and that there are also countries that do not see it in the same way as Germany, where it is absolutely possible, where I think it is already partly offered in the cars. I think in Canada I once saw that in Audis you can buy a feature. Yes, you enter quasi in the navigation system, where you want to go and there is the quasi already displayed, where a parking space is free. So we just don't have that in Germany, because the data is not merged. And there are political reasons for that.

**Philip** [00:29:22] Okay, okay, exciting, exciting. And the next indicator we looked at was the circular economy, because that is also a very big topic in the EU. And then we looked at how you can perhaps use reusable materials in production, but also simply extend the lifetime of the products. And maybe you can give us a short assessment of what you think about the two concepts.

**E10** [00:29:53] So in general, this whole topic of the circular economy is a huge topic that will keep us busy for a very long time. And actually, you have to ask yourself, including both of us with an economic or business management background, why something like this wasn't done much earlier? Because it's nothing. It's not only done, I think, because certain resources are becoming scarce and therefore more and more expensive, and that's why people are resorting to recycled resources, but there's also a whole lot of money in the things that I recycle and that I might otherwise have either thrown away or resold at a low price. So one example that I recently heard about was automobile production, which you look at exactly in which step do you recycle an end-of-life vehicle? One knows this example that of a car coming into a press and then you have a small metal cube, but you look at exactly which materials are used in this end-of-life vehicle and how can I best separate them from each other again? Which step do I take before the other, so that I can best separate these materials from each other again, so that I have a pure material that I can use again? Or in other words, so that this raw material, this resource has a high value, because I can use it again or sell it on for a high value. So it has two components for me On the one hand, there's an insane amount of money in it. I wonder why something like that wasn't considered before. Probably because new reactants were simply cheap because you don't have to rely on them. But you're going to be dependent on it now, and that's where the second component comes in. There is simply a shortage of many resources. Yes, of course, especially those that are now needed for an energy or mobility turnaround. And

that makes a lot of sense. And I think they are also dependent on new recycling methods in some cases. Yes, for example, how do I recycle the zion batteries? I don't think such methods existed until a few years ago, and now more and more players are establishing themselves. And I think that's a huge business.

**Philip** [00:32:59] Yes, yes, definitely. So do you think that shared mobility would have the potential to really replace the concept of private car ownership in the future? Or do you think that will always be an issue, that people will still have their own car? Or do you see real potential that we can really achieve such a high implementation of shared mobility that it can virtually replace private ownership?

**E10** [00:33:36] Yes, that is an exciting question. I think it's also a bit of a philosophical question from today's perspective. I hear different opinions. Some are absolutely certain that private ownership will continue to exist in any case. Others say you don't need it anymore. At some point, especially in industrialized countries, the status or status symbol of owning a vehicle will have completely disappeared. There will be other things that are more important. I could also imagine that there are both, yes, it does not always have to be one or the other extreme, that can also coexist well with each other. But I am also convinced that we will see much, much more shared mobility in the future. I can't even quantify what the future holds and how it will somehow become visible on the market. But I think we will see a blurring of these boundaries. When is it still possible to be a V operator, when, when is it a commercial operator? Exactly. And of course, then we know ourselves when we own something. But why shouldn't such an MVV or MVG be able to operate such a service completely at some point? I mean, that's something they're already doing in part. They also operate bike sharing, and in some cases car sharing with cars, i.e. stationary car sharing. Why shouldn't they also be able to offer

autonomous shuttle buses in certain parts of the city? Yes, that's not even that far-fetched. And it's all within the realm of possibility. And could public transport providers offer complete mobility at some point. In addition, you have providers like Uber, Free now and other car-sharing providers like Miles or Sixt or Share now, all of which also offer shared mobility, which actually results in a nice, competitive market where there is definitely something for everyone. Yes, so exactly this philosophy thing. And I think it's also a bit of an application thing. So I think, if I don't have children and I'm still relatively young, why should I buy my own car when there's a great mobility offer? But if I have two children and also have to somehow reach a place of work every day that is 20 kilometers away from me, then many things change again. And if I'm no longer so good on foot or so either still have opportunities to drive my own car, yes, then I do that. But super, super exciting question.

**Philip** [00:37:10] Yes, yes, definitely. Then I would go right to our next and last pillar. That would be the economic side. And there we looked at the indicator of GDP and once the creation of new jobs. But for me, they always go together a little bit. That's why you're welcome to address both at the same time. And maybe in general, whether you think that these concepts can contribute to an economic growth or that in the short term this whole change could also have a bad influence.

**E10** [00:37:49] On the GDP and creation of jobs?

**Philip** [00:37:50] Yes, exactly. We would also be happy to refer to Germany only.

**E10** [00:37:59] Yes, so I think what the market wants will prevail. What does the market want? Perhaps also as an example, this discussion that has boiled up very, very much in recent weeks.

So do we want to have a ban on the sale of internal combustion vehicles in the EU from 2035 or not? I simply believe that this will not be implemented because the market does not want it. So if you now imagine 2035, who would want to drive an internal combustion engine when he can have a cool e-car. Yes, the most expensive part of the e-car is the battery. The battery has become so much cheaper in the last ten years that it is now affordable for many people to buy an e-car while increasing efficiency. Yes, the range problem that we once had no longer exists at the moment. The battery will decrease in price even more as the most expensive component in the car and the efficiency will increase again. It doesn't have to be lithium ion batteries anymore, it can also be solid state or sodium ion. And there are probably many other possibilities for batteries. That means that the car will simply become much cheaper by then than it is today. The e-car itself is of course less complex than a combustion vehicle, fewer parts, less wear and tear. For this reason, I think 20305 who would want to have such a car, if I have to go regularly to the workshop, because I have wear parts? It is expensive, the purchase price is high, who knows how high Efuel will be, how expensive energy may be, so electricity energy. The price of electricity will always go down. So from that point of view I think e-mobility makes super much sense. That's, that's what the market wants. So, now I come back to your question. What the market wants will prevail. And in that case, that's e-vehicles. Those are batteries. These are vehicles that then also bring a high level of connectivity. And for this reason, I absolutely believe that this is something that you have to be part of as an economy if you want to increase your GDP. And these are also absolutely the business sectors that have the potential to generate jobs, precisely because that's where the music will be playing in the coming years.

**Philip** [00:41:18] Does that mean that German companies are also well positioned in the areas of smart mobility and alternative drive technologies?

**E10** [00:41:32] Yes, in principle, yes. I think there's always a lot of talk in Germany, in the media in general, about missing the boat. But I think that, if you don't necessarily compare it with Tesla and the blatant Chinese companies, Germany is in a pretty good position in the automotive industry. And I actually believe that we have a big brake with the VDA or with the politicians who are flirting with the VDA, because they are not only still responsible for the combustion engines, but also for the suppliers, especially Tier 2 suppliers, who are then responsible for smaller things like those built into the combustion engine. And they still want to be protected. And I think that puts a massive brake on things and also leads to resentment. And I think these companies would be better advised to put their business model to the test now than in five or ten years. So that's one view. The other view, of course, is that I've been working in an innovation center for six years now, and I'm actually in a bubble like that, and of course I see a lot of new things, just a lot of great things. Of course, you can't judge so well that a lot is happening. So, of course, what it looks like somewhere else than in our environment. But I do think that a lot is happening here and a lot is being built up and a lot is being done to ensure that this location remains competitive. In the sense exactly that in the background, it but not without job Let's go for it. The German automotive industry was simply too heavily geared towards combustion engines and I don't think you can take them all with you into e-mobility. And there are simply strong new players from the Far East. But I don't think we have to say that the German automotive industry is not competitive, but in my opinion, yes, it is competitive, but not as dominant as it was in the past.

**Philip** [00:44:29] And in the longer term, do you think you can make up for that job loss by maybe upskilling the workforce?

**E10** [00:44:41] So upskilling, I generally always find important always a really good idea. Also from a psychological perspective. Yes, I believe that countries, especially Germany, which have built their success very strongly on human capital and less on raw materials or other things, are dependent on scoring economic points with innovations that are simply better or more groundbreaking than elsewhere and thus build up prosperity. That's why I think we are well advised to continue developing and researching and to try to bring this research to the market. I believe that this is a guarantee of prosperity. And lifelong learning is a form of upskilling, which is absolutely necessary and a good thing, also with regard to demographic change. So we all kind of have to work until 70 and beyond before we can draw a pension. And I think it makes sense that at some point we will be retrained for the things that are then in demand.

**Philip** [00:46:01] Okay. Very exciting. I think I've been holding you up for so long anyway. Very, very exciting all the insights. Very, very cool that you took so long now as well. Really helped me a lot.

**E10** [00:46:19] I'm glad to hear that, if it has moved on, exactly the course of your work again have questions, feel free to write again! Yes, exactly.

**Philip** [00:46:30] With pleasure. With pleasure. We were aiming to finish in mid-May. I can send you a copy to read over if you're interested.

**E10** [00:46:52] I'd love to! And have a great time in Lisbon.

***Transcript Interviewee E11***

***--- Start of recording ---***

**Lennard**: Thank you for your helpfulness in briefly completing the following question in writing format. First Question:
Do you think that Hydrogen propulsion will make mobility more accessible for society?

**E11**: In the use of hydrogen in the mobility sector, a strong separation must be made between the transport of goods, passengers and loads as well as the use in private cars. In addition, time is a significant influencing factor. The structural change is made more difficult by the chicken-and-egg problem that is present in all areas of the hydrogen market ramp-up.
Priority is given to industrial sectors that are difficult to decarbonize, such as heavy goods transport and aviation. Hydrogen will be used in these sectors much sooner than in private vehicles. Hydrogen in private transport will only play a role towards the end of the energy transition, when enough hydrogen is available. This is because the time is needed to first built up sufficient production capacities and the necessary infrastructure. In the medium term, until this is achieved, battery-powered vehicles will have to close the gap. As was already clear with battery-powered vehicles, new technologies are always more expensive at the beginning. This will also be the case with hydrogen vehicles, but by then, battery-powered vehicles will prospectively be cheaper and have a longer range.
Due to the chicken-and-egg problem, there are currently not enough hydrogen refuelling stations in Germany, which is also due to the high production costs. Chicken-and-egg problem: Due to a lack of end users, there is a lack of incentives for the development of a hydrogen infrastructure, which in turn is the prerequisite for new demand by end users.

**Lennard**: How would you assess the next point, the safety in relation to hydrogen? Do you think that Hydrogen propulsion will make mobility safer for society?

**E11:** Hydrogen does not pose a greater risk than other energy carriers, it simply behaves differently. Various investigations and studies have shown that sufficient passive and active safety measures can be implemented in the case of leaks. However, hydrogen is also a greenhouse gas with 5.8 CO2 equivalents.
In terms of safety for humans and nature, hydrogen is not harmful in production. However, the upstream processes are certainly questionable. Rare earths and PFAS are needed for the production of fuel cells and membranes. The exploration of rare earths has a strong negative impact on the environment and nature. In addition, the availability of resources and security of supply must be assessed critically, since many substances are only explored in single countries. PFAS, also known as permanent chemicals because they cannot be dismantled in nature. The EU is planning a ban on the entire group of substances (even before the EU REACH regulation (Regulation (EC) No. 1907/2006) came into force, an EU-wide ban on PFOS (perfluorooctane sulfonic acid, C8) was decided (see EC Directive 2006/ 122), which was incorporated into the EU POP (Persistent Organic Pollutants) Regulation shortly thereafter.)

**Lennard**: Do you think that Hydrogen promotes a decarbonized/emission-free mobility?
And do you think Hydrogen can contribute to the implementation of a circular economy in the automotive industry?

**E11**: In order to achieve 100 percent climate neutrality, all processes involved in the production of the technical components required must be decarbonized (exploration of rare earth,

aluminum, steel, etc). The energy used to produce the components and vehicles must also be climate-neutral.

Recycling is difficult due to the PFAS membranes that are often installed, since highly harmful substances are released during regular thermal recycling processes, which make complex exhaust gas after-treatment necessary. First approaches to the avoidance or recycling of PFASs do exist, but they have not yet reached the required level of technical readiness. As a consequence, hydrogen vehicles, even if they run on green-produced hydrogen, cannot strictly speaking be called climate-neutral. (Just like electric vehicles. The difference here is that recycling of batteries is already technologically sophisticated).

**Lennard**: Do you believe that Hydrogen can generate economic growth/increase the BIP? And do you think that Hydrogen can create more green jobs in the auto industry?

**E11:** With regard to the expected further increase in the tax burden due to the CO2 tax, companies can save costs in the long term by converting to hydrogen. However, the conversion of a production line is always associated with increased costs, which vary depending on the area of application and the company. In the automotive industry, we can already see that many suppliers are preparing for the changeover. For example, piston manufacturers are re-specializing in the production of components for electric motors.

In my opinion, it can be assumed that old jobs will be compensated, and even new jobs created. However, the crucial point here is to have trained the necessary skilled workers. The problem of the shortage of skilled workers is already one of the main issues in all branches of industry. Germany is an exporting country and one of its main industries is the automotive industry, so our national prosperity stands and falls with it. For the automotive industry to survive, it must follow the path of the energy transition, otherwise it will be overtaken by global competitors.

The step towards e-mobility is one, but in my opinion, there is no way without hydrogen vehicles in the long term.