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A dissent-based approach for multi-stakeholder scenario development — The future of electric drive vehicles

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ABSTRACT

In this paper, we present a novel approach for generating scenarios in multi-stakeholder environments. In order to address one of the most imperative environmental and societal challenges related to mobility, we explore the future of electric drive vehicles (EDVs). Since many different stakeholders are involved in the socio-technological transition from internal combustion engines (ICEs) to EDVs, we present a dissent-based scenario development process, which uses the Delphi technique for data generation. In total, 140 experts from 15 stakeholder groups participated in this German-based survey and assessed controversial projections for 2030. Results reveal a considerably high degree of dissent. In order to cope with different viewpoints in the scenario development process, we utilize a novel 5-step dissent analysis for further insights into possible futures. Thus, we account for potential differences among stakeholder groups (step 1), the effect of a desirability bias (step 2), as well as the impact of outliers (step 3) and bipolarity (step 4) in the survey results. Finally, we identify different clusters of experts through latent class analysis (step 5). Based on the results of the dissent analysis, seven partially conflicting multi-stakeholder scenarios for the future of EDVs in 2030 are developed.

1. Introduction

Mobility implies that an indispensable part of modern society and an ever increasing number of people around the world have access to technology-based means of individual mobility. Between the years 2000 and 2009, the total amount of motor vehicles increased by more than 25%, surpassing the one billion mark for vehicles worldwide [1,2]. At the same time, the mobility of people and goods is a significant economic factor in itself. The automotive industry has grown to become the single largest manufacturing sector in the world [3,4].

However, the current mobility system entails a variety of substantial challenges. These challenges encompass, among other aspects, problems such as noise exposure, land fragmentation, accidents, and air pollution. Road transport is one of the largest contributors to greenhouse gas emissions and more than 95% of the total external costs of mobility are caused by road traffic [4,5]. Therefore, it will be essential to transform the current mobility system in a way that social and environmental damage is limited.

One of the key challenges on the path towards sustainable mobility is related to the internal combustion engine (ICE) [6] — currently the worlds' dominant power train technology. Since engine technology is constantly evolving, ICEs have largely succeeded in advancing in step with social needs and expectations over several decades [7]. As a consequence, today's vehicles emit much lower levels of air pollutants than decades ago. Nevertheless, the transition towards more sustainable mobility formats

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has only had limited effect so far [8]. Policy measures and incremental technical innovations to reduce vehicles' emissions and noise have often been neutralized by other factors, such as the overall increase in vehicle numbers, engine size, travel frequency, and trip length [8]. Therefore, current research calls for a radical systemic change to overcome the hegemony of ICEs [6,9,10].

In this context, electric drive vehicles[1] (EDVs) are a promising approach to contain some of the most urgent environmental and societal problems related to mobility [11]. Offer et al. [12] argued that EDVs have the potential to lower CO_2 emissions of road traffic significantly. According to Steenhof and McInnis [13], EDVs could reduce CO_2 emissions over 3 tonnes per person per year by 2050 in Canada (988 Mt CO_2) if all new vehicles were either hydrogen (156 Mt CO_2) or electric (153 Mt CO_2).

However, the challenges related to the market diffusion of EDVs are substantial. The requirement of formidable advancements in battery technology [14], the necessity of integrating several technological sub-systems [7], the need for calibrating political interventions and regulation on both national and local levels [15], uncertainties related to the energy origin [7], and potential shifts in mobility preferences [16] document the magnitude of these challenges. Consequently, controversial discussions among various stakeholders about battery-propelled vehicles can be observed [14].

In light of these uncertainties, a technological transition from ICEs to EDVs appears to be questionable. Even if the momentum of EDVs' technology can be increased further over the next years, the transition process will continue to be a major concern for car manufacturers, policy decision makers, scientists, and a variety of other stakeholders for the next decades to come. As uncertainty and controversies regarding this potential transition are high, we invited designated experts from multiple stakeholder groups to share their thoughts on the socio-technological transition from ICEs to EDVs. We conducted the study in Germany with mainly German experts.

In our research study, we aim to map the various views of future images and the transition from ICEs to EDVs. Furthermore, we would like to investigate reasons for differing perceptions regarding the future of EDVs by exploring the nature of dissent. Finally, we construct scenarios that reflect the variety of these perspectives in order to increase the usability of these scenarios.

Thus, we contribute to existing research in three ways: First, in allusion to theoretical considerations on socio-technological transitions [17–19], we integrate the technological, political, industrial, and customer-oriented perspective to draw a more holistic picture of the socio-technological transition. We, therefore, phrase our first related research question as follows: How will EDVs develop by the year 2030? Second, we quantify dissent within the ongoing debate via a Delphi study and propose a 5-step analysis to shed light on the dissent. Third, we use the results of the dissent analysis to develop partially conflicting multi-stakeholder scenarios for the future of EDVs, reflecting the ongoing discussion and differing perceptions of the stakeholders involved in the transition process. Our second research question for this methodological perspective is: How can different viewpoints be systematically integrated in the scenario development process? By elaborating on conflicting multi-stakeholder scenarios, we aim to sustain the constructive disagreement among the stakeholders involved in the transition [20].

With multi-stakeholder scenarios, participants often do not share a common vision or underlying set of values, which means that a shared cultural base, or at least appreciation, has to be created through the scenario process and dialogue [21,22]. Scenario development, and planning in such settings, often take more time, intellectual effort and financial resources than planned in order to deal with its inherent complexity, which makes the inclusion of a meta-level perspective and transparency even more important [23]. Multi-stakeholder scenarios potentially enhance scenario usability, thus reducing the likelihood of errors occurring in the decision-making-process [24,25]. In elaborating on multi-stakeholder scenarios, we contribute to the research domain of "inter-organisational scenario work" which involves a mixture of different organisations. A real-time Delphi survey [26,27] is used for data collection. Prior research has confirmed that the Delphi method enhances validity, acceptance, plausibility, and consistency of scenarios by systematically integrating expert knowledge into the scenario development process [28,29].

The remainder of the paper is organised as follows: In section two, we review previous research on the future of EDVs and highlight that existing publications adopted a rather narrow view on the socio-technological transition, while at the same time failed to account for the controversies inherent in the transition process. In section three, we introduce the Delphi survey approach and present the procedures of projection development and expert selection from multiple stakeholder groups. In section four, we present a 5-step dissent analysis and subsequently apply it for dissent-based scenario development in a multi-stakeholder environment setting. The paper concludes with a discussion and an outlook for further research.

2. Literature review on future-oriented and EDV-related research

Ever since their emergence at the end of the 19th century, battery-propelled vehicles have been a topic of public and academic interest [30,31]. The academic discussion on the future of EDVs has intensified in recent years, especially with regards to their potential to de-carbonize the mobility system. Steenhof and McInnis [13] modelled the long-term impact of EDVs on CO_2 emissions in Canada and concluded that full-scale market diffusion of EDVs would result in a reduction of 153 Mt of CO_2 as compared to a "business-as-usual" scenario (i.e. 988 Mt CO_2 in Canada 2050).

Another research stream focuses on modelling customer preferences for EDVs [32–37]. Eggers and Eggers [33] developed a choice-based conjoint adoption model to forecast future purchases for electric drive vehicles. Mau et al. [38] analysed dynamic customer preferences for alternative power engines and found a positive impact of altered environment conditions.

[1] We use the term "electric drive vehicle" for all types of vehicles that are entirely or at least partially propelled by electric batteries, i.e. hybrid-electric and merely battery propelled cars. The terms "electric drive vehicle" and "battery propelled vehicles" will be used interchangeably throughout the paper.