Becoming a Sustainable Driver: The Impact of Mobile Feedback Devices

Johannes Tulusan[1], Marc Brogle[2],
Thorsten Staake[3], Elgar Fleisch[3]

[1] Institute of Technology Management, St. Gallen University – Switzerland
johannes.tulusan@unisg.ch
[2] SAP Research, SAP (Schweiz) AG – Switzerland
marc.brogle@sap.com
[3] Bits to Energy Lab, ETH Zurich University – Switzerland
{tstaake, efleisch}@ethz.ch

Abstract. Feedback devices in combination with smart phones and / or wireless technologies are becoming more and more relevant to be applied in eMobility artifacts such as Electric Vehicles. Additionally, governmental enforcements to reduce CO_2 emissions urge for ICT solutions, which enable drivers to become more aware of sustainability. In this conceptual paper, we therefore critically evaluate existing literature in this field and narrow down the research question by comparing it with other related questions. Then, we introduce a sustainable socio-technical model, based on existing socio-technical theories. This extended model could be applied to analyze the impact on feedback devices to increase the awareness of CO_2 emissions caused through non-ecological road transportation.

Keywords: eMobility, electrical vehicles, CO_2 reduction, sustainability, green mobility, intelligent ICT devices, feedback technology, socio-technical.

1. Introduction

In the past, mankind has achieved technical improvements in many areas. However, the majority of advancements neglected the focus on sustainability. Recently, the debate of Electric Mobility (eMobility) concepts due to new governmental regulations to reduce CO_2 emissions has ignited the industry and research community. Sustainable eMobility concepts emerge, most recently in the automotive industry. New electric vehicle (EV) market players, innovative sustainable urban (e)Mobility concepts, and latest improvements of EV technologies trigger stakeholders to rethink the concept of sustainable mobility and driving.

Important technologies to reduce CO_2 emissions are sustainable mobile ICT solutions, mobile devices, location based services, and the wireless integration of relevant data to backend information systems (e.g. ERP). Therefore, this paper raises the research question of, "how and which sustainable feedback information from intelligent ICT devices enable and motivate stakeholders before, after and during driving to become a more sustainable driver?"

We evaluated various research questions and discussed them with the industry and research community in order to be able to narrow down the research focus. In [4], we got reminded, that many current ICT enhancements in eMobility are defined from engineers. Hence, they are often technically sophisticated, but their user-friendliness leaves a lot to be desired. Therefore, we suggest a sustainable socio-technical theoretical model to explore the research question.

This paper is structured as follows. Section 2 introduces related work relevant for understanding the importance of our stated research question and the proposed solution approach. In Section 3, we present the research question in more detail. We introduce our approach of a socio-technical model in relation to sustainability in Section 4. Finally, Section 5 concludes this paper.

2. Related Work

Critical evaluations of relevant literature show current perceptions of the adoption, maturity, and usefulness of ICT eMobility solutions. Particularly, work related to feedback technologies such as energy, water, CO_2 monitoring applications, and the impact on users can be associated to this research area [7].

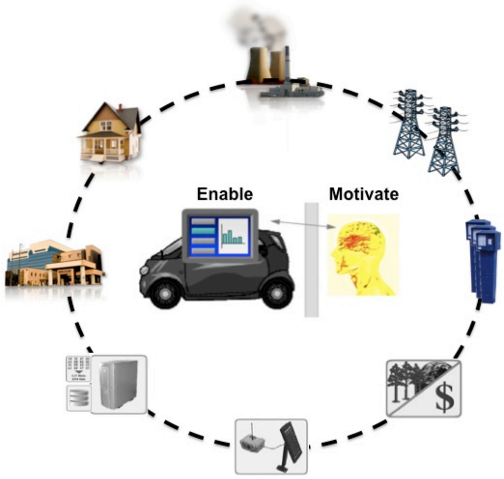

Fig. 1. Examples of external factors which influence the driver

The Fig 1. shows external factors which influence the driver in the vehicle. For instance, the current environmental political agenda to reduce CO_2 emissions until 2050 is a strong external factor in which each single citizen needs to be motivated to act sustainable. In general, a reliable eMobility infrastructure which connects charging spots at home, work place or in public areas with an electric grid influences the driver to switch to an electric vehicle or not. In the meantime though, interaction with feedback devices in cars could enable the driver to act more sustainable by displaying relevant information about CO_2 emissions. Monetary aspects, e.g. how much money a driver has saved by driving slower, is another influential indicator [7].

Smart Phones such as the Apple iPhone and Google's Android phone have begun to integrate fairly sophisticated sensors such as accelerometers and GPS into the device itself. However, it is unclear whether the iPhone accelerometer is accurate enough to measure the car trips and to calculate a personalized carbon footprint. No field tests have been conducted so far which analyze the impact on sustainability or how ICT feedback devices influence the driver to develop a more sustainable behavior. Therefore, relevant analogies are also drawn from energy and water feedback devices.

Studies in energy or water consumption applications such as smart meters or energy monitors evaluate the impact of displaying the consumption level by instantaneous feedback [12]. These commercial applications focus on the visualization of consumption of an entire household or on the device level [2,7], Power Cost Monitor [6], and TED-1000 [9]. For instance, in [14], a wireless networked sensor node that measures the power consumption and uses the communication interface to automatically transmit the data was developed. However, the majority of these solutions require a complex installation before usage or at least technical understanding. Therefore, they are not very user-friendly. Nevertheless, field tests unfold that receiving instant feedback and incentives on the usage reduces electricity and water consumption: "*32 percent reduction in electricity use (amounting to savings of 68,300 kWh, $5,107 and 148,000 lbs of* CO_2*) but only a 3 percent reduction in water use*." [12]

Additionally, environmental settings, social norms, sociodemographic, and additional variables require different approaches and feedback information for changing energy-related behaviors [13]. For instance, social norms provide a behavior from which people do not want to deviate, since being too deviant is being above or below the norm. The authors of [13] defined five clusters of behavioral patterns: conservers, spenders, cool, warm, and average. Results show a considerable discrepancy in the energy use of these clusters. For instance, conservers use less energy than spenders, which use more than the average household.

In sum, several factors influence the behavior of more sustainable usage of energy, water, and alternative transportation to reduce CO_2 emissions: external factors, governmental, technical, behavioral, and social norms.

3. Research Question(s)

To enable a stringent evaluation of the research area, we collected a first set of relevant research questions, presented in Table 1. These research questions support our further research process by evaluating the consumers´ behavior -, technical - and socio-technical perspectives. Questions in the first column explore consumers' behaviors in the eMobility domain, the second column ICT relevant areas, and the socio-technical perspective features the comparison of both columns. Through interviews with industry and academic experts in this field and analysis of these questions, we were able to derive the research question for this paper. "How and which sustainable feedback information from intelligent ICT devices enable and motivate stakeholders before, after and during driving to become a more sustainable driver?" This research question is relevant twofold. It explores which feedback technologies are existing in the market, as well as which information or services are required to motivate stakeholders to become more sustainable or not.

Table 1. Relevant research questions

Consumers' Behaviors Perspectives	Technical Perspectives
Why do drivers switch to EVs?	Which ICT applications and / or devices are relevant in relation to eMobility or EVs?
What are the charging behaviors of EVs from consumers?	Which wireless technologies do exist in the automotive industry to support eMobility?
What are the driving patterns?	How can ICT help to reduce the anxiety of the driver to reach, for instance, the final destination?
What are the most anxious factors to use new (e)Mobility concepts?	How can ICT support the awareness of sustainable driving and vehicle usage?
What are the important aspects for sustainability?	Which ICT functionalities are relevant to support a sustainable vehicle usage?
How is it possible to change the awareness of driving more sustainable?	Which data should be analyzed from a backend information system?
How and which information about sustainability influence consumers?	How are data transferred securely and wirelessly to a backend information system?

4. Theoretical and Conceptual Lens

In the middle of the 20th century, examples of unsuccessful introduction of new ICTs were often linked to the resistance of users. ICTs were associated with being too technical and not providing user-friendly functions [1]. As a result, research in ICT goes far beyond technical rationales and analyze the research object in multilevel aspects such as organizational, sociological, socio-technical and process-based.

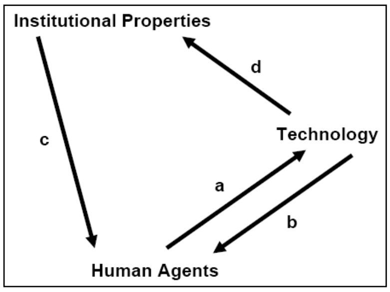

Fig. 2. Structuration Model of Technology [10]

Socio-technical ideas began to be used in the IT / IS field in the 1960s [4]. One example is Orlikowski`s Structuration Model of Technology (SMoT) (see Fig. 2). Her concept does not only need to be applied in organizational or institutional environments, it is also possible to apply it within the group and individual levels of analysis [10,11]. The SMoT is based on three components, Human Agents, Technology, and Institutional Properties. Technology only comes into existence through creative human action. She also defines a duality of technology: the technological artifact (design mode) and technology-in-practice (use mode). Later, she claims that the separation between technologies as IT artifacts and the use of such artifacts is especially useful in both empirical research and everyday usage.

In the context of the research interest, the focus on a socio-technical model helps to understand humans (e.g. drivers), technical aspects (e.g. feedback ICT devices) and the interactions between those two areas as presented in Fig. 3.

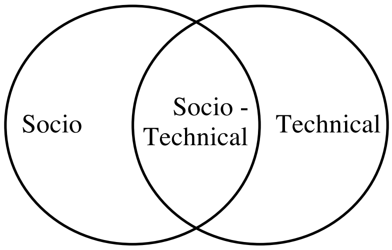

Fig. 3. Socio-Technical Model [3,8]

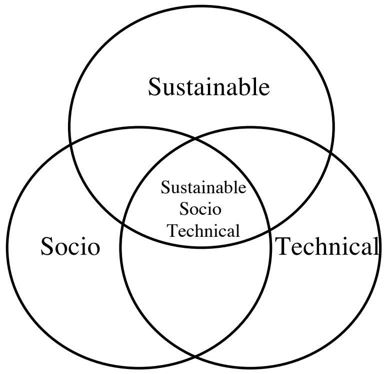

Fig. 4. Socio-Technical Model in relation to Sustainability

Nevertheless, in order to include also sustainable aspects and a metric to measure sustainability in relation to eMobility, a third dimension needs to be included as shown in Fig. 4. This dimension should support the primary research by being able to measure what sustainability actually means for humans, how it relates to ICT devices, and finally, what the impact of sustainable feedback information would be in order to become a more sustainable driver. The ICT device can be an enhanced navigation system, an on board communication device (e.g. Continental "Always On" concept of a networked car), or applications in smart phones. Especially the latter provides already means to track the driver's driving behavior (e.g. using MIX Mobile or Green Milage Android applications). One scenario could display a CO_2 mobility footprint in such a device according to the driving speed and evaluate if the driver would drive more sustainable if the CO_2 barometer would go up. Another scenario could test if driving with or without such devices influences the driver to become "greener".

5. Conclusion, Limitations and Outlook

In conclusion, while the socio-technical model is going to broaden one's horizon, it is elementary to extend the model by including the sustainable dimension. Only then, the enablement of drivers to become more sustainable can be measured. Probably a fundamental change of the stakeholders' thinking towards IT artifacts as feedback devices has to evolve. Therefore, this paper presents a future research area that could help to gain a better theoretical and practical understanding of socio-technical models in relation to sustainability, specifically to sustainable drivers. The outcome might be relevant not only for the research community but also for the industry. The first, could contribute to theoretical extension of socio-technical models towards sustainability.

The latter, could facilitate a practical impact for the industry market players, to get more insights how their consumers perceive the current notion of sustainability.

Relevant technical aspects should be further investigated and explained. However, due to the early stage of feedback devices in this field, technical use cases, architectural concepts, and prototypes need to be defined and built first. Afterwards, the sustainable socio-technical model suggested can be tested in the field. Therefore, meetings with industry partners and EU funded research projects are in progress to facilitate technical realization very soon. Due to the strong governmental attention to reduce CO_2 emissions, several research and industry projects are currently conducted or planned. These future projects such as ELVIRE, Vlotte, and SAP Future Fleet provide a very good platform to conduct the research. We are in advanced conversations to conduct research with these project partners.

6. References

1. Avgerou, C., Ciborra, C., Land, F.F.: The Social Study of Information and Communications Technology: Innovation, Actors and Context, Oxford, OUP (2004)
2. Blue Line Innovations Inc. http://www.bluelineinnovations.com
3. Bostrom, R., Heinen, J. S.: MIS Problems and Failures: A Socio-Technical Perspective, MIS Quarterly, Vol. 1, No. 3 (1977)
4. Davis, F. D.: Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Quarterly, 13(3), 319--339 (1989)
5. DIY Kyoto, http://www.diykyoto.com
6. Energy Inc, http://www.theenergydetective.com
7. Froehlich J., Everitt K., Fogarty J., Patel S., Landay J.: Sensing opportunities for personalized feedback technology to reduce consumption. Proc. CHI workshop on Defining the Role of HCI in the Challenge of Sustainability (2009)
8. Mumford E.: Redesigning Human Systems, IRM Press for a good summery of the development of the sociotechnical movement in many countries: pp 12--32 (2003)
9. Onzo Ltd, http://www.onzo.co.uk
10. Orlikowski, W.J.: The Duality of Technology: Rethinking the Concept of Technology in Organizations. Organization Science 3 (3): 398—427 (1992)
11. Orlikowski, W.J., Barley, S. R.: Technology and institutions: what can research on information technology and research on organizations learn from each other? MIS Quarterly 25 (2): 245--265 (2001)
12. Petersen, J. et al.: Dormitory residents reduce electricity consumption when exposed to real-time visual feedback and incentives. IJSH, 16--33 (2007)
13. Schultz, P.W., Nolan, J.M., Cialdini, R.B., et al: The constructive, destructive and re-constructive power of social norms. Psychological Science, 18(5):429--434 (2007)
14. van Raaij, W.F., Verhallen, T.M.M.: A behavioral model of residential energy use. Journal of Economic Psychology, 3:39--63 (1983)
15. Weiss, M., Graml, T., Staake, T., Mattern, F., Fleisch, E.: Connecting smart meters with mobile phones. Proc. MUM 2009, Cambridge, UK (2009)
16. Yun, T.J.: Investigating the Impact of a Minimalist In-Home Energy Consumption Display. Proc CHI (2009)