How to implement greener commuting to universities – a campus case study in Schwäbisch Hall as contribution to achieving the SDGs

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Abstract

In its recent report, the IPCC has described the impacts and possible magnificent disturbances that arise from climate change. But CO2 emissions are still on the rise. The transport sector can be seen as one of the fastest growing contributors. The majority of fuels used are still based on non-renewable sources, even though research and implementation of alternative transport technologies are making progress. Also on the policy-side efforts are being made to tackle climate change and stimulate transition to a sustainable way of living.

With its 17 Sustainable Development Goals (SDGs) the UN-Agenda 2030 represents one global approach trying to solve economical, ecological and social problems. Transport can be seen as a cross-cutting issue to directly or indirectly contribute to the SDGs, e.g. in case of fuel subsidies, rural transport or good health. Shifting mobility and transport to emission free resources is one major factor for climate change mitigation. Thereby, innovative mobility concepts, based on renewable energy supply as well as offering multimodal mobility solutions, equal access and stimulating behavioral changes are necessary. Especially rural areas often have to deal with missing transport links, resulting in an above-average use of the car. This makes taking action all the more important.

By executing an empirical case study, the authors try to investigate the implementation potentials for sustainable public mobility at universities in rural areas as a local contribution to the UN-Agenda 2030. The Campus Schwäbisch Hall, part of the University of Applied Sciences Heilbronn serves as exemplary setting for this field test. Schwäbisch Hall is located in a rural area in Southern Germany. Daily commuting by car is the favored way of travelling by students and staff.

The aim of the project is to devise a mobility concept that creates incentives for all parties involved to dispense individual car traffic and switch to public transport or e-bikes instead. The introduction of a new bus line and the possible use of e-bikes is examined in a test phase. The implementation of the test phase is linked to a quantitative and qualitative collection of mobility data (modal split), the current mobility behavior and the acceptance of green mobility by students. Incentives for other mobility

opportunities and potential obstacles are investigated. By exchanging knowledge with local stakeholders and experts, measures and recommendations for action and the implementation potential of sustainable mobility is elaborated.

1. Introduction

The world as we know it, might rapidly change. If climate change progresses, major upheavals are expected according to the IPCC[1] that seriously affect the wellbeing of environment and people. But also other changes are taking place that impact the social environment: By 2050 “80% of the world's population is expected to live in cities”, meanwhile it is expected that population growth will decrease in rural areas.[2] Growing imbalances between rural and urban areas, particularly in terms of attractiveness, distance from employers and access to infrastructure might arise.

Such developments also affect German communities and cities. The so-called “traffic turn” as part of climate protection measures is widely discussed among policy makers, researchers, companies and other stakeholders. The substitution of fossil-fuel based mobility technologies is one of the main concerns.[3] Currently about 42% of the German population lives in villages or small towns.[4] Cars create 40% of the traffic volume in Germany in urban areas. In rural and provincial areas car usage accounts to 60 to 70%; public transport covers only ten % of the traffic volume.[5] Some studies even suppose that the number of cars per 1,000 inhabitants will heavily increase in the coming years.[6]An increasing daily traffic leads to challenges like managing traffic flow and parking spaces as well as increased noise and emissions.

Already today every fourth worker in Germany commutes, all together <s11 million people daily.[7] 18% of Germany's greenhouse gas emissions originate from the transport sector.[8] Negative effects are measurable both on local and global level. Cities and municipalities are facing the major task to secure an effective, accessible and achievable public transport.[9] Results of this year’s assessment of air pollutants in German cities show that in 57 cities the measured Nitrogen oxide (NOx) is above the maximum limit values.[10]

Shifting mobility and transport to emission free resources is one major adjusting screw for cities to reach their climate protection goals and support the 1.5-degree-target, which describes the efforts of international climate politics to limit global warming.[11] However, at the same time, innovative mobility concepts have to integrate more complex and sometimes conflicting aspects, besides renewable energy use. They need to offer good access to transport services both for commuters and residents of an area that help to “reduce automobile dependency, but also the need to travel”.[12] They should stimulate behavioural change, be affordable, avoid additional land

[1] IPPC, " Global Warming of 1.5°C."
[2] BMZ, “Die globalen Ziele für nachhaltige Entwicklung. Ziel 11. Städte und Siedlungen inklusiv, sicher, widerstandsfähig und nachhaltig machen.“
[3] BMBF, “Verkehrswende für Deutschland.“; Kasten et al., “Erarbeitung einer fachlichen Strategie zur Energieversorgung des Verkehrs bis zum Jahr 2050.“; Rudolph, Koska and Schneider, Verkehrswende für Deutschland. Der Weg zu CO2-freier Mobilität bis 2035, 3; UBA, “Warum Deutschland eine Mobilitätsstrategie braucht.“; VCD, “VCD-Kernforderungen für die Verkehrswende.“
[4] Bangel et al., “Stadt – Land – Vorurteil.“
[5] Ministerium für Verkehr Baden-Württemberg, *Personenverkehr in Stadt und Land. Befragungsergebnis Mobilitätsverhalten 2017*, 8-9; Nobis and Kuhnimhof, *Mobilität in Deutschland – MiD Ergebnisbericht*, 4.
[6] Kugoth Jana, “ „Das Auto muss weg“ funktioniert auf dem Land nicht.“; Staatsministerium Baden-Württemberg, “Mobilität. Verkehrswende auch auf dem Land einleiten.”
[7] ZEIT Online, “Elf Millionen Deutsche pendeln zur Arbeit.“
[8] Rudolph, Koska and Schneider, *Verkehrswende für Deutschland. Der Weg zu CO2-freier Mobilität bis 2035*, 3.
[9] Mees, *Public Transport Solutions for Suburbia. Beyond the Automobile Age, Abstract*.
[10] Spiegel Online, “Stickoxid-Werte in 57 Städten zu hoch. Bericht des Umweltbundesamts.“
[11] Rudolph, Koska and Schneider, *Verkehrswende für Deutschland. Der Weg zu CO2-freier Mobilität bis 2035*, 3.
[12] Lehmann, “Green Urbanism: Formulating a Series of Holistic Principles,” 6.

consumption and use smart technological solutions in a constantly changing surrounding. Multimodal mobility offers developed for urban areas do not cover the mobility needs of rural areas and it is difficult to run them efficiently.[13]

The UN has adopted 17 ambitious goals for the global community to overcome challenges "related to poverty, inequality, climate, environmental degradation, prosperity, and peace and justice" and to achieve sustainable development.[14] In its 2030 Agenda the UN sees sustainable transport systems as key to resilient "economic foundations for all countries"[15], when combined with "universal access to affordable, reliable, sustainable and modern energy services, quality and resilient infrastructure".[16] According to the Partnership on Sustainable Low Carbon Transport, "five of the SDGs are directly targeted at transport and mobility by considering aspects of road safety (Target 3.6); energy efficiency (Target 7.3); sustainable infrastructure (Target 9.1), urban access (Target 11.2), and fossil fuel subsidies (Target 12.c)".[17]

As urbanization is progressing and increasing worldwide, the role of cities becomes even more significant for sustainable development and hence securing healthy living conditions.[18] On the local level, this means to invest into bottom-up approaches for sustainable urban development that consider the diverse characteristics of their local areas.[19] For this purpose cooperation is essential.[20] Lehmann notes that transforming urban design into a green, more sustainable urbanism requires a multidisciplinary approach following the "triple zero framework of zero fossil-fuel energy use, zero waste and zero emissions (aiming for low to-no-carbon emissions)".[21]

Universities and higher education institutions play a significant role in terms of knowledge transfer and education for a more sustainable future.[22] At the same time, universities are adding to the local traffic through daily commuting by students and staff to university facilities.[23] Therefore, considering a more sustainable way of university commuting as part of sustainable transport planning of cities can contribute positively to the overall urban performance and a smart city development.[24]

Considering this background, the implementation potential for green commuting is discussed in this paper. In a small-scale case study at the university campus of Schwäbisch Hall, the mobility behaviour of students and staff is examined. A field test of green commuting alternatives is executed in order to devise a valuable solution that creates incentives for all parties involved to dispense individual car traffic and find alternatives to fossil fuel based traffic modes.

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[13] Kugoth Jana, " „Das Auto muss weg“ funktioniert auf dem Land nicht.“; Nobis and Kuhnimhof, *Mobilität in Deutschland – MiD Ergebnisbericht*, 4-5.
[14] United Nations, "Sustainable Development Goals.“
[15] Partnership on Sustainable Low Carbon Transport, "Sustainable Development Goals & Transport."
[16] United Nations, "Transforming Our World.The Agenda 2030 for Sustainable Development", 11.
[17] Partnership on Sustainable Low Carbon Transport, "About SLoCaT."; Partnership on Sustainable Low Carbon Transport, "Sustainable Development Goals & Transport."
[18] Chourabi et al., "Understanding Smart Cities: An Integrative Framework."; Heidrich et al., "National climate policies across Europe and their impacts on cities strategies."; Reckien et al., "How are cities planning to respond to climate change?."; United Nations, "Sustainable Development Goals.“
[19] Biesbroek et. al., "Europe adapts to climate change: comparing national adaptation strategies."; Carter, "Climate change adaptation in European cities."; Hulme, "Geographical work at the boundaries of climate change."
[20] Gustafsson and Ivner, "Implementing the Global Sustainable Goals (SDGs) into Municipal Strategies Applying an Integrated Approach", 301.
[21] Lehmann, "Green Urbanism: Formulating a Series of Holistic Principles," 4.
[22] Ramos et al., "Experiences from the implementation of sustainable development in higher education institutions: Environmental Management for Sustainable Universities."; U-Mob, "European Network for Sustainable Mobility at University."
[23] See note 23 above.
[24] See note 23 above.

2. Problem description

Schwäbisch Hall is a German medium-sized town with about 40,000 inhabitants, located in a provincial and rural area. The campus Schwäbisch Hall, part of the University of Applied Sciences Heilbronn, is the setting for a field test for green commuting alternatives. With 8,500 students, the Heilbronn University of Applied Sciences is one of the largest universities in Baden-Württemberg, Germany. The campus Schwäbisch Hall is one of four university locations.

The number of students has increased from 150 in 2009 to 1,067 in winter semester 2018/2019. The number of professors, lecturers and staff in Schwäbisch Hall amounts to 89 people. Through the extension of further degree courses, numbers might increase significantly in the coming years.

The campus is a typical commuting facility, students and staff are arriving and departing on a daily basis. They add a significant amount of traffic and related emissions to the overall daily traffic situation. The university buildings are split on two locations, with a distance of 700 meters and a significant difference in altitude. Students (and partly staff) have to change daily between both campus locations due to different lecture locations. The available parking ground at the campus comprises only about 142 spaces for students and staff, which is less than sufficient and leads to “wild” parking in the neighbourhoods. Generally public and free parking space in Schwäbisch Hall is rare. With rising numbers of students, the situation might deteriorate in the future.

Specific peculiarities of the mobility behavior at the campus and the whole university were already examined in the past years:[25]

- 30% of the students describe access to public transport as inadequate.[26] Main reasons are frequencies and costs.[27] There is a wish for a direct campus line that offers a quicker connection between the campus and the train stations. [28]
- Due to great differences in altitude, the proportion of cycling in the city is quite low. This situation is reflected in the small number of bicycle parking facilities at the campus. There is space for only 24 bikes; no shower and locker rooms are available so far.
- Besides lacks in existing public transport infrastructure the favoured means of transport is based on “individual user preferences, the personal mobility behaviour, trip chainand travel purposes”.[29]
- There is a strong wish for more free parking spaces.[30]

Developing mobility alternatives for reaching the campus in Schwäbisch Hall needs to consider both city-internal traffic as well as overland traffic, meaning commuting from the surrounding or smaller villages into the city. Mobility needs and behavior might be addressed differently for different target groups.

[25] Bernecker, “Mobilitätssituation der Studierenden, Mitarbeitenden, Professorinnen und Professoren an der Hochschule Heilbronn. Mobilitätsbefragung 2015.“; Klinkmann and Hotzky, “Nachhaltige studentische Mobilität. Entwicklung eines Konzepts für den Campus Schwäbisch Hall. Eine theoretische und empirische Studie vor dem Hintergrund der Standortvergrößerung.“
[26] Klinkmann and Hotzky, “Nachhaltige studentische Mobilität. Entwicklung eines Konzepts für den Campus Schwäbisch Hall. Eine theoretische und empirische Studie vor dem Hintergrund der Standortvergrößerung.“
[27] See note 27 above.
[28] See note 28 above.
[29] Bernecker, “Mobilitätssituation der Studierenden, Mitarbeitenden, Professorinnen und Professoren an der Hochschule Heilbronn. Mobilitätsbefragung 2015.“
[30] See note 31 above.

3. Bottom-up approach for sustainable mobility – case study at campus Schwäbisch Hall

Based on the key findings of the existing surveys, the twelve month´s project "Sustainable mobility at campus Schwäbisch Hall" started in November 2018. The goal is to develop a concept for sustainable mobility and greener commuting by offering alternatives to individual car traffic. The campus Schwäbisch Hall serves as a case study for alternative mobility offers at universities. Additional information about the potential of sustainable mobility services is collected during a one-week test phase. The Ministry of Science, Research and the Arts Baden-Württemberg provides financial support. Local stakeholders such as the public transport provider, the city of Schwäbisch Hall, student representatives, the owner of parking areas, public utilities and others are closely integrated into the project.

Roupé (2015) defines three different types of sustainable commuting, which were adapted for the case study respectively the test phase in Schwäbisch Hall:

- Commute types that have no emissions: walking and bicycling.
- Commute types that transport more than one passenger: public transportation and carpooling.
- Commute types that replace fossil fuel with renewable energy: electrically powered forms of mobility with green electricity. [31]

Mobility offers covering these criteria for sustainable commuting should offer alternatives to car use for students and staff, when commuting to the campus.

<u>Commute type with no emissions</u>

In the period from 20.05.2019 to 24.05.2019 students and staff had the option to rent e-bikes to cover the distance from and to the campus and between the campus buildings. With two rental systems, people could rent an e-bike either for the entire week or for short periods to get to the other campus building. The last-mentioned app based rental system was available for six weeks. For further motivation, students could also register for a countrywide bicycle campaign, which took place at the same time and upload their cycled kilometers and saved CO2 emissions.

<u>Commute types that transport more than one passenger and partly replace fossil fuels</u>

During the test phase students and staff also had the opportunity to use an e-bus to get to the campus, which circulated on a special campus route. The bus connected all important junctions, like the two campus buildings, the alternative parking space in walking distance and the train station. With further stops between these junctions, a good accessibility could be ensured. The electricity for the bus and the bikes was purchased by the municipal utility of Schwäbisch Hall. It generates already 64% of its energy from renewable sources.[32] As a small addition, the idea of ride sharing was promoted to reduce the number of cars. Moreover, mobility consulting was offered.

The parking space for students was closed for 2.5 days. Students were motivated to use an alternative parking space with a walking distance of approximately 1,200 meters and the offered mobility alternatives. The idea was to simulate mobility behaviour under normal and extreme conditions, regarding the parking space availability, and examine possible impacts. All mobility services were offered free of

[31] Roupé, "Sustainable Commuting. Analysis of current mobility management actions at Chalmers University of Technology and Stanford University.", 4.
[32] Stadtwerke Schwäbisch Hall GmbH, "Geschäftsbericht 2017.", 7.

charge in order not to let any potential fees be a hindrance to the target groups. Throughout the concept development, the feasibility of such services was is examined as well.

The findings of the project shall contribute to reducing the traffic volume in the city and reducing CO_2 emissions and support more efficient mobility and traffic planning. At the same time the concept measures shall be in conformity with the strategic planning measures of the city of Schwäbisch Hall and contribute to reach the SDGs targets with regard to urban activities.

4. Potentials of green commuting at campus Schwäbisch Hall – results of the test phase

Two surveys were conducted among all campus members after the test phase to examine the status quo of campus commuting in more detail and to estimate the potential for sustainable mobility offers. The evaluation of the first survey will initially show the current situation at the campus Schwäbisch Hall. Against this background, the results from the first week of testing, in which the focus was on the use of the e-bus and e-bikes, can be analysed. The second survey shows the results of the six-week test phase, which refers exclusively to the use of e-bikes with the renting system via app (bike sharing stations). The survey results form the basis for developing concrete sustainable mobility measures.

4.1 Verification of modal split

The first online survey focused on collecting mobility data (modal split), current mobility behaviour and evaluation of existing infrastructure at the campus as well as the acceptance of alternative mobility offers.
The total sample unit comprised 1,156 people, all students and staff members at the campus have been invited to participate. The response rate was 9.17% in total. As only 5.62% of the contacted staff members participated in the survey, the received answers are not representative. For that reason, the analysis of data is focused only on student's responses.

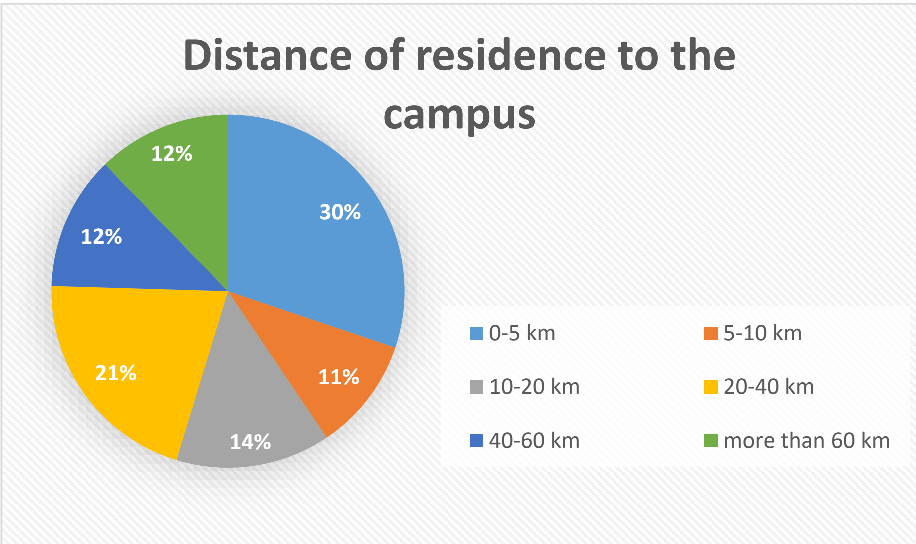

Figure 1: Distance of residence to the campus. Source: Own research.

In the survey, 106 students were questioned about the distance of their residence to the campus. Only 30% of the students are living within a radius of up to five kilometres. 21% have a one-way commuting distance of 20 to 40 kilometres. 25% have to cover a one-way displacement of at least 40 kilometres. In the context of Figure 1, the existing need to travel and the corresponding travel volume becomes obvious, as the campus has a big catchment area.

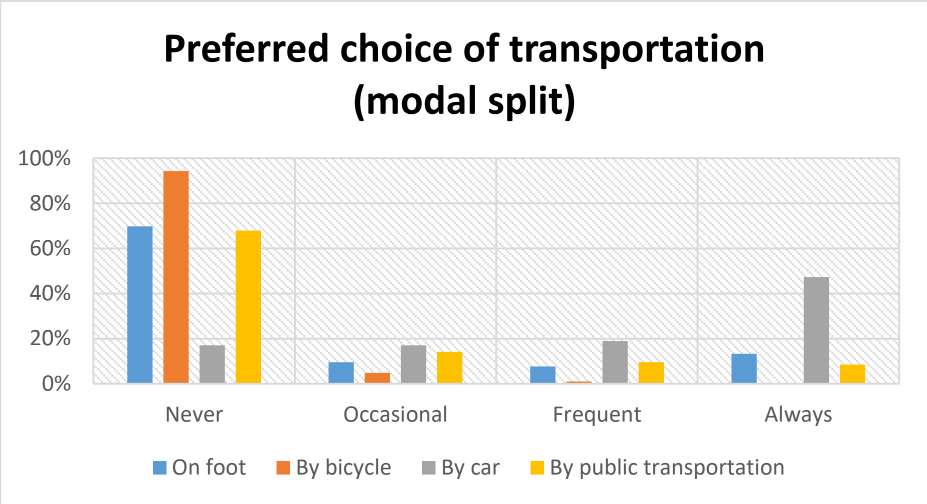

Figure 2: Preferred choice of transportation to the campus. Source: Own research.

In addition, the modal split for students' mobility was surveyed by asking about the preferred choice of transportation mean to the campus. Frequently large distances from residence to campus in combination with a rural catchment area explain the above-average use of car.

The modal split in Figure 2 verifies that nearly 50% of the respondents always choose the car as preferred regular mean of transportation. The use of bicycles is almost non-existent. Less than 1% of the respondents frequently come by bicycle to the campus and only 5% occasionally use a bike. Approximately 70% of all students never go by foot or use public transport.
Further on, when asked about reasons that speak against the use of public transport, 28% of the students answered that it would take much more time to get to the campus than travelling by car. 26% said that the schedule for public transport is too irregular to fit their lectures times. Similar to the use of public transport, the expenditure of time with bicycles would be much higher for 23% of the participants. Furthermore, the topography was an exclusion criterion for using the bicycle for almost 20%. The lack of safe and consistent bicycle infrastructure was also a reason for not going by bike.

Personal interests can also explain the preferred choice of transportation. Here, the survey shows that for 89% independence and for 86% of the participants' time saving are among the most important reasons for choosing a particular mean of transport. The factor cost saving is only important for 45% of all students and climate protection even just for 13%. These findings reflect to a large extent results from the previous studies on mobility behaviour in Schwäbisch Hall.

4.2 General acceptance of e-bus and e-bike

The number of passengers using the e-bus was tracked during the test phase. Generally, the response rate for this mobility service was quite low, showing a decrease over the week. Higher passenger numbers might be associated with closed students' parking spaces as well as with bad conditions in the first days.

Further reasons for the low acceptance derive from the survey results. One reason was that the bus only went in a circular route and not in two directions on the same route, which led to longer waiting or driving times. In addition, the schedule did not always fit the departure times of trains and could not cover the whole day of lectures. Besides that, the testing phase of one week most probably was too short. Feedback from the survey suggests that people might need some time to get used to new offers respectively until they actually recognize them. The aspect of negative emotions among students because of the closed parking space might also have led to a rejection of the offered services.

4.3 Results of the six week test phase for station-based e-bikes

In the second survey of the six-week test phase with e-bikes was evaluated. The app-based rental system was established primarily for the route between the two university buildings. With a rental period from 10 minutes to 72 hours, users had a high flexibility in using the e-bikes. The survey focused on three factors: acceptance, usability and type of use.

Table 1: Excerpt from the rental statistics of the fleet software. Source: Own research.

Active users	44
Rents (total)	324
Average rental time	Two hours, 51 minutes
Driven kilometers	2,478

The interpretation of the rental statistics of the fleet software shows some valuable results (Table 1). With a number of 44 active users, 324 rents were started in the six-week test phase. The average rental period was under three hours. With a total distance of 2,478 kilometres, it can be assumed that the e-bikes were also used for purposes other than commuting between the two university buildings. Bikes were often rented over the weekend and during good weather periods. The rental statistics also show an increase in user numbers over time, which might reflect the fact that establishing new mobility services needs time until the target group uses it.

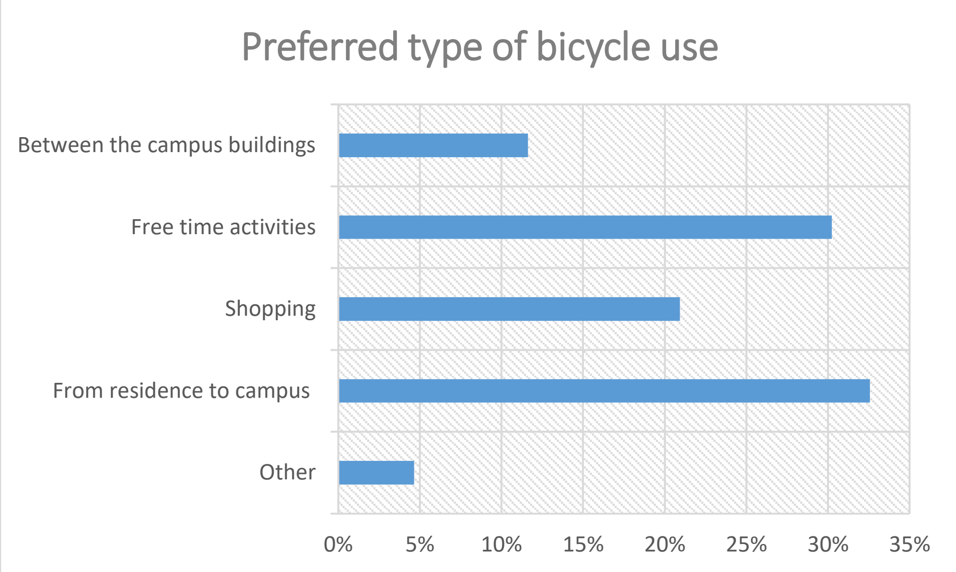

Figure 3: Type of rides with e-bikes during the test period. Source: Own research.

Figure 3 shows the type of rides the e-bike was predominantly used for. Only eleven % have used the e-bike for the originally planned purpose of commuting between the campus buildings. A technical aspect regarding the loan process of e-bikes could be a reason for the low use for this route: The bikes were station-based; this means that the rent could only be ended at the same station it was started at. Both, trips to free time activities as well as trips from residence to the campus were reported by about one third of the users. With 21%, the use of e-bikes for shopping rides is also higher than the use of e-bikes for commuting between the university buildings.

Nevertheless, when asked which rental system is preferred for continuation, a rental system for the entire semester is slightly favoured at 48.6%. 37,9% of the students prefer a rental system for single trips, 13,5% favour another system.

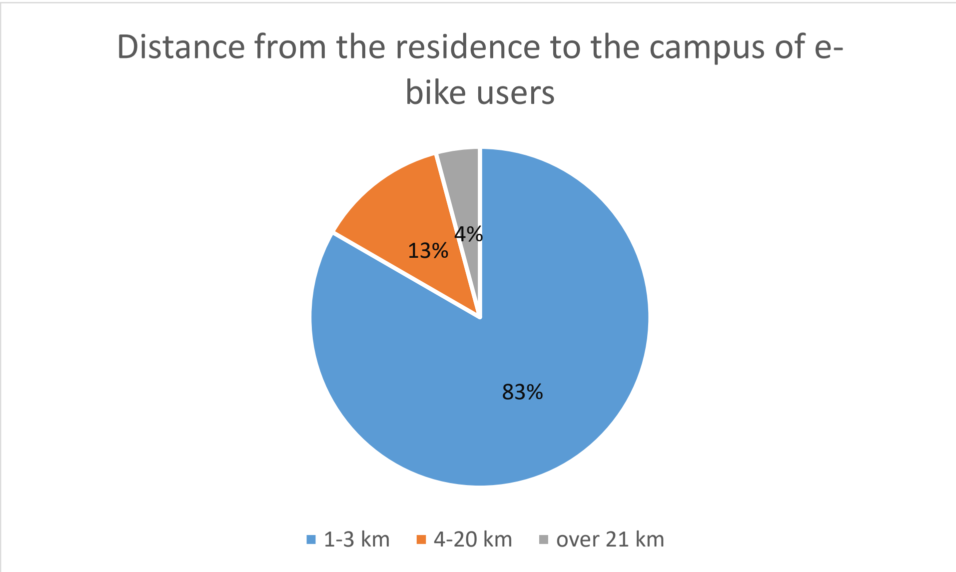

Figure 4: Distance from the residence to the campus of e-bike users during test phase. Source: Own research.

When looking at the distance from the place of residence to the campus, Figure 4 clearly shows that the majority of e-bike users stems from a radius of three kilometers.

About 13% have a distance of four to 20 kilometers, only four % have a distance of over 21 kilometers.

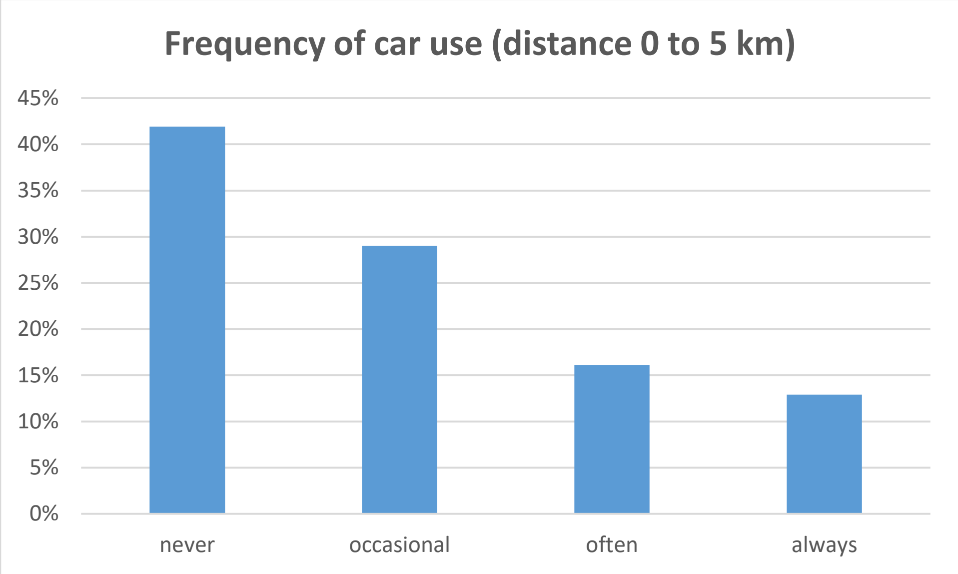

Figure 5: Car use of persons with a distance less than five kilometers. Source: Own research.

Figure 5 shows the frequency of car usage by students who live within five kilometers distance from university. Despite the relatively short distance, only 42% never use a car. Nearly 30% of the respondents are using the car permanently or frequently. These rather unambiguous values could be another reason to assume that e-bike utilization has relatively little relevance for journeys between university buildings alone. Especially for people living in close vicinity to the campus or inside the city (up to 5km distance from the campus) the e-bike might be an attractive mean of transport for commuting between the place of residence and the university. Here the authors see a big potential to establish alternative mobility solutions and motivate the target group to substitute commuting by car with commuting by e-bike. The amount of driven kilometers within six weeks is quite surprising. By assuming an average CO_2 emission of 140 g per car kilometer driven, about 347 kg CO_2 were avoided in the six weeks through 2,478 km of cycling.

4.4 Barriers for greener commuting

The survey has also shown the main barriers for greener commuting in Schwäbisch Hall (Figure 6). Partly, they are interlinked with each other, which needs to be addressed by the mobility concept. Some of the most relevant barriers are described below:

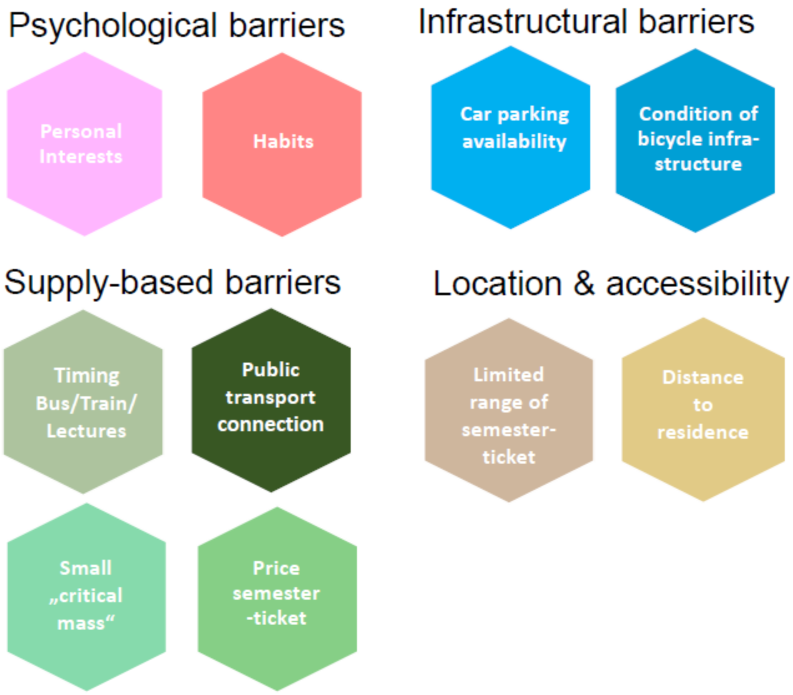

Figure 6: Main obstacles for greener commuting to campus Schwäbisch Hall. Source: Own research.

Habits and parking facility management

Even though the number of survey responses allows a statistical evaluation, the majority of students and employees were not reached by the survey. Reasons for that might be manifold, ranging from lack of interest to lack of information. Closing the student's parking space has caused resistance and criticism. Future considerations to shifting mobility behaviour might also provoke resistance, anger or other negative feedback. For example, the introduction of a fee-based parking facility management that does not offer free availability for all students, might be "unpopular" and perceived as detrimental by the target group, as students ask for more free parking space.

The test phase proved that it is not only important to offer equally attractive alternatives, but also that an appropriate mixture of communication, incentives and policies is crucial. Another important factor might be that people need time to get used to changed circumstances. The good and warm weather during the e-bike test phase of six weeks might have had a positive influence as well and made it more attractive to use a bike and to change one´s normal travel habits. Alternating seasons and weather conditions will most probably influence the user frequency and amount of necessary e-bikes.

Distance/residence campus and access to public transport

The survey results also stress the need for differentiating the target group of students living in Schwäbisch Hall itself or in the closer vicinity from those commuting from a greater distance. The tested city-internal solutions for green commuting like e-bus and e-bikes are not solving the general lack of sufficient public transport connections from Schwäbisch Hall to the surrounding and often more remote areas. The development of viable solutions requires further involvement of stakeholders and lobbying for the integration of sustainable mobility solutions in the city`s and district master plans.

Nevertheless, this system will only be successful, if the public transport is attractive enough in terms of time spent, flexibility and costs. Only then, this might be an incentive for students to use more environmentally friendly traffic modes. The fact that the dependence on cars in rural areas might prevail longer than in urbanized areas needs to be accepted for the moment, as it needs large-scale infrastructural approaches to change this situation.

Costs semester ticket and clocking bus/train/lectures

The limited range of the existing semester ticket and its high price in combination with the non-exhaustive public transport diminishes its attractiveness. As long as it is cheaper and more flexible to go by car, the incentive for switching to public transport is quite low.
Survey results and discussions with students have shown that train arrival times at the station do not match the lectures, so in many cases students would have to travel one hour earlier to get to the lecture on time. This interlinkage is not easy to solve, as e.g. the pricing of tickets is also depending on the amount of possible users. With its 1,000 students the demand weight of the university is limited compared to other user groups such as school students that generate a bigger demand.

Funding

The e-bus and e-bikes were free of charge during the test phase, which most probably had an impact on the utilization rate and positive feedback. During regular operations, this mobility service is most likely not free of charge. Students were asked about their willingness to pay for such services in the survey. The prices mentioned would not cover the costs for running such a system. Finding the right balance between attractive pricing models and feasibility is a possible challenge. Predictions about how the target group will accept a fee-based offer are difficult to make.

Topography

The topography partly aggravates the shift to non-fossil-fuel based mobility services. Bicycles without electric support are not attractive due to the hilly topography, but are costlier. It might even be too steep to use other micro-mobility services such as (e-) scooters.

5. Overall concept with 19 measures forms the solution approach

Based on these findings, the authors developed a set of 19 interconnected measures that help to overcome the described barriers to alternative means of transport use (see Figure 7), that also integrate already existing services in Schwäbisch Hall and the region. Activities were divided into five categories to address the various needs of staff and students and to generate flexible multi- and intermodal alternatives to car use: Public collective, public individual, collective individual and private individual mobility. The fifth category includes overarching measures that affect at least two categories. These measures mainly focus on communication aspects, as it turned out during the test phase that people need to be addressed explicitly and need explanations to test new mobility services. Besides that, also strategic measures such as the concept development for low emission events or corporate travels are part of this section.

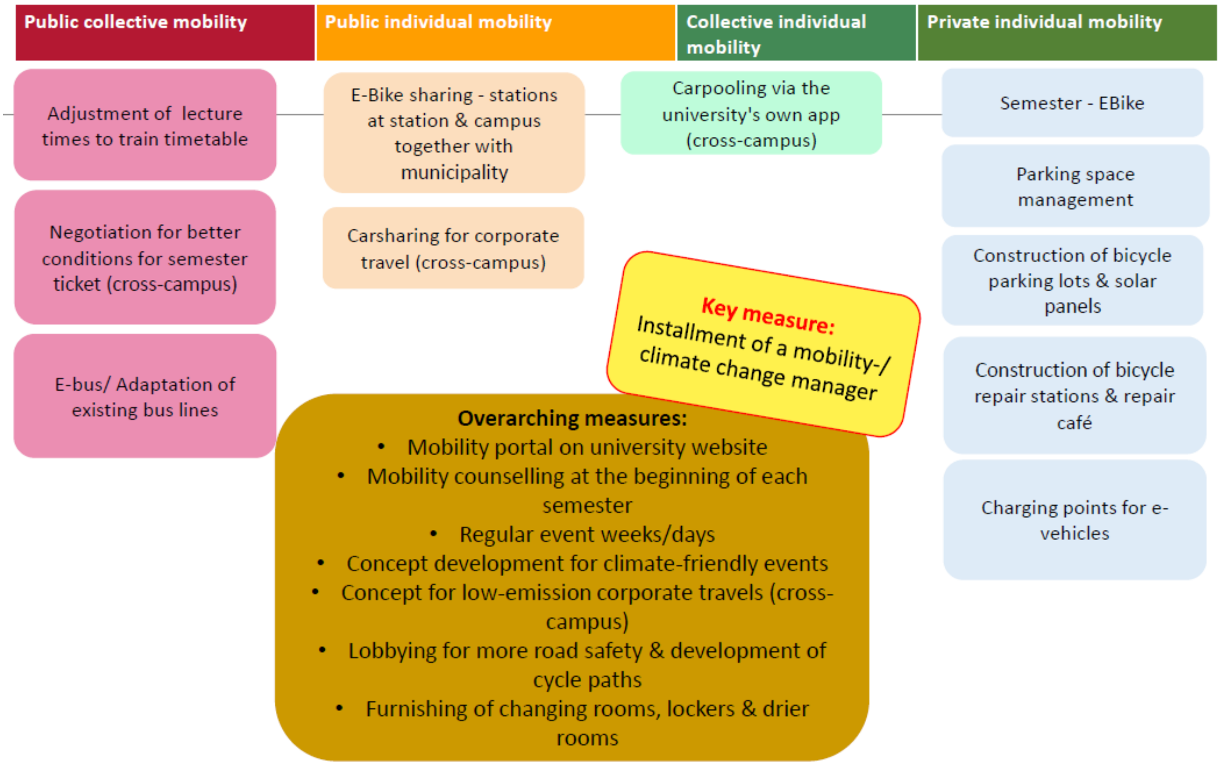

Figure 7: Overall concept with 19 developed measures. Source: Own research.

When developing the overall concept, several aspects were considered, such as:

- Measures should be audience specific and/or occasion-specific
- Overarching measures are needed especially in communicatoin
- Measures should be implemented step-by-step
- Measures should be scalable
- Measures should be financially viable

For example, the measure to improve the conditions of the semester ticket only affects students on the campus Schwäbisch Hall, while a mobility portal on the university website affects all University members. Some measures apply to the campus and beyond. Thus, the measures have an effect beyond the campus and can partly be transferred to other locations of the Heilbronn University of Applied Sciences.

The different demands and requirements of the measures allow for a successive implementation. For example, the introduction of a rating system for parking space management can be implemented at short-term, whereas the negotiation of better conditions for the semester ticket is more likely to take place in the medium to long term. Another important aspect is the scalability of the measures. This criterion concerns above all the introduction of rental systems for e-bikes and carsharing.

All these criteria are preceded by the financial viability of the measures. In addition to cost-intensive measures, a comprehensive catalogue of measures should also include measures that only cover personnel costs.

Experiences from the test phase have shown that it takes time and personal capacity to introduce and also to supervise existing mobility services, therefore the installation of a mobility/climate change manager is key for a successful realization of the concept.

6. Conclusion

On a local level, shifting mobility to a more sustainable mobility contributes to the SDG´s in various ways: by generating solutions for missing transport links and helping to create equal access (Target 11.6) as well as by utilising of renewable energy (Target 12.c), new technologies and sustainable mobility services (Target 9.1), it contributes to the general local activities for urban sustainability by reducing CO2 emissions and fostering healthier living conditions.
The campus Schwäbisch Hall serves as a role model for greener commuting solutions at universities, but also in a more generalized way for sustainable and fossil fuel free transport modes in rural areas. The test phase and surveys were focused on the particular local framework conditions at the campus, so the results are limited and need to be adapted to contribute to the overall climate protection activities of the city, but also to create synergies with the total university's sustainability performance. The findings of this study reflect the specific situation of rural and provincial areas, where the dependence on individual car traffic is higher than in more urbanized or metropolitan regions.[33] They also reflect the general challenges in the transition phase of society, politics, public institutions and technology in the field of sustainable, fossil fuel free urban development and transport solutions. The authors hope that the findings might add general input for other researchers and practitioners working on similar topics.

Acknowledgements

We would like to thank the Ministry of Science, Research and the Arts of Baden-Württemberg that provides the financial support for the twelve months' project "Sustainable Mobility at the Campus Schwäbisch Hall" as part of its strategy dialogue "Automotive Industry". We also like to thank the local stakeholders in Schwäbisch Hall for their active participation in executing the field test and developing the mobility concept.

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