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Interdisciplinary Education and Knowledge Transfer in Merging the Mobility and the Energy Transitions

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Abstract

The "Forschungscampus Mobility2Grid" research project is currently working on solutions to merge the mobility sector and the energy transition by using electric vehicles' batteries as energy storages in decentralized urban micro smart grids to balance fluctuations in energy production. This will only work if all stakeholders are informed and educated about the technical, economic, and social implications – as well as the challenges and benefits – of the energy and mobility transitions. In pursuit of this goal, one of the project's working groups, "Education and Knowledge Transfer", develops and tests different interdisciplinary educational formats. This article gives an introduction to the project and presents its initial experiences with the formats. To fulfil the needs of business and to adapt solutions to existing concepts and products, it has been found that formats need to be compact, flexible, and modular while being praxis-oriented and specific to the target group. One of the main factors of success for the formats is the living lab approach of using the EUREF-Campus in Berlin as a showcase for realization.

Keywords: energy; mobility; transition; education; knowledge transfer

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1. Background and relevance: Merging transition in the mobility and the energy sector

After the nuclear disaster in Fukushima in 2011, the Federal Government of Germany decided to phase out nuclear power and introduce a large-scale energy transition towards renewable energies. Renewables are set to make up 80% of all national energy production by 2050 (Bundesrat 2011). In global comparison, Germany is one of the 20 nations that contributes most to global warming (Matthews et al. 2014, p. 6). In the coming decades, however, Germany aims at reaching climate targets in all sectors. Under the moniker of a "mobility transition," the transport and mobility sector are to be included in this quest, and electric mobility is a key technology in this process. The energy and mobility transitions progress at different speeds, which makes their combination both more relevant and more complex. Renewable energies currently make up 30 % of the gross electricity production in Germany (statistic for 2016, Statistisches Bundesamt 2017). Out of all of the 3.4 million passenger cars newly registered in 2016, the share of hybrid vehicles was 1.4 % and the share of electric vehicles was 0.3 % (statistics for 2016, Kraftfahrt-Bundesamt 2017). While these numbers are increasing, the goal of reaching one million electric vehicles by 2020, as formulated in 2011 by the government program "Electric Mobility in Germany" (Bundesregierung 2011, p. 10), currently seems unrealistic. Additionally, electric mobility will only become more climate friendly if the power to operate the electric vehicles comes from renewable energies (Fournier et al. 2014, p. 65).

In this regard, further research is needed to find joint solutions between the mobility sector and the energy transition. One such solution involves the batteries of electric vehicles being used as energy storage cells in decentralized urban "Micro Smart Grids" to balance the fluctuations in energy production by wind and solar power plants. This solution is the focus of the inter- and transdisciplinary research project "Forschungscampus Mobility2Grid". One of the research project's seven working groups, or topics, "Education and Knowledge Transfer", will be presented in this article. Because of the transformation process that is implied in linking the energy and mobility transitions, it is especially important to develop concepts for interdisciplinary education and knowledge transfer. The process is one characterized by complexity and uncertainty and has not yet been embraced in business or in civil society (Schippl and Grunwald 2013, p. 4; Vogt and Bongard 2015, p. 43-44). In the process, economics and civil society, including its everyday citizens, have to change routines of producing and using mobility and energy. Not only technical solutions, but also concepts for need-based and practical education and knowledge transfer solutions are required in order to disseminate innovations in market and society.

This article will first give a brief presentation of the project "Forschungscampus Mobility2Grid" and its research topics, followed by a more detailed description of "Education and Knowledge Transfer", its research questions, and its methods. The fourth section presents preliminary results of conceptualizing and testing formats for interdisciplinary education and knowledge transfer. The final chapter gives preliminary conclusions and responses to the research questions and a brief outlook toward the next research steps. The aim of this article is to provide not a foremost scientific-theoretical contribution but a practice-oriented reflection of experiences in developing interdisciplinary education formats. As the transportation sector and the energy sector will increasingly merge with numbers of electric vehicles growing, such formats will be needed in order to push this transition process forward.

2. Project "Forschungscampus Mobility2Grid" and its topic fields

"Forschungscampus Mobility2Grid" comprises 36 partners from industry and science and is funded by the German Federal Ministry of Education and Research within the initiative "Forschungscampus – öffentlich-private Partnerschaft für Innovationen". Within the framework of the Ministry's high-tech strategies, this initiative supports public-private partnerships and the long-term cooperation between industry and science in complex research fields with high potentials for innovation. Mobility2Grid has already completed a first phase (2013-2015), the so-called pre-phrase; the project's first main research phase (2016-2020) is currently underway. A second five-year main phase can be applied for. The central idea of the project is to integrate electric vehicles in decentralized smart energy grids through bidirectional charging technologies in order to contribute to the goal of making power and mobility completely based on renewable energies, safe, and affordable in the long term. The project takes a living lab approach on "EUREF-Campus" in Berlin, Germany as a showcase for realization. It integrates seven working groups that deal with matters such as smart grid infrastructures, private and commercial electrified transportation, and acceptance and participation.

3. Education and Knowledge Transfer: questions, methods and initial results

The working group "Education and Knowledge Transfer" focuses on the role education and knowledge transfer plays in the process of combining mobility and the energy transition in Germany.[1] Both are essential for promoting solutions for this transition process. Thus, both academic formats and professional training formats need to fulfill similarly complex interdisciplinary requirements. Transfer of knowledge into society is likewise needed to increase awareness for and acceptance of the process.

3.1. Pre-phase results

The pre-phase was based on requirements in the education sector as they are formulated in the "Kompetenz-Roadmap Nationale Plattform Elektromobilität (NPE) (Nationale Plattform Elektromobilität, AG 6, Müller and Goericke 2012, p. 2). Derived from it, courses of action and priorities for academic and professional education in electric mobility were recommended: "In many job descriptions, electric mobility will play a role in the future and will require a new understanding of mobility" (Institut für Berufliche Bildungsforschung 2014, p. 26, translation by authors). In terms of academic education, the roadmap recommended developing and establishing new fields of expertise, courses of study, and training centers. In terms of professional education, it recommended expanding practical implementation guidelines for professional and extra-occupational qualifications in electric mobility including, inter alia, qualification modules (ibid, S. 19). It also recommended the use of research funding to support these targets and stressed the relevance of collaborative and closed network research between actors in business and in science (ibid, S. 21). Schwartz, on the other hand, focuses the role of professional training as innovation driver. Anchoring entrepreneurship in educational formats allows for an increase of both startup probability and success in developing innovative solutions and business models (Schwarz 2014, p. 231). Professional education can support the development of key technologies in companies so that they become innovation drivers by themselves (Ehrke et al. 2012, p. 304). Broad programs like "Schaufenster Elektromobilität" (Begleit- und Wirkungsforschung Schaufenster Elektromobilität (BuW) (Ed.) 2016), funded by the federal government from 2012 to 2016, have been useful for demonstrating pilot schemes and competences in electric mobility in Germany. However, these approaches have all focused solely on mobility and transportation, neglecting the crucial aspect of merging it with the energy sector. Hence, further research and activities were and are necessary in order to successfully merge the mobility and the energy transition.

The pre-phase bore initial results in developing interdisciplinary academic courses in cooperation between science and industry. Based on a market analysis of existing educational opportunities in the research area, expert interviews, a stakeholder consultation workshop, and an evaluation of the first developed academic formats, the pre-phase has shown that educational and training opportunities, as well as knowledge transfer formats, must be compact, flexible, and modular in order to meet practical needs (Behrendt et al. 2015). It also showed that the establishment of educational formats takes time. A key factor for their successful establishment was the common location and the proximity to the practical sites on the EUREF-Campus where science and industry can collaborate on a level playing field in a living lab. This success was measured using qualitative interviews with different actors from science and business. The results of the interviews were also presented in an exhibition at the EUREF-Campus and online (Böhm and Kuttler 2014). Currently, the living lab concept is discussed as a key concept in urban transition research (Flander et al. 2014).

3.2. First main phase research questions and methods

After having considered the results presented by the pre-phase, the working group "Education and Knowledge Transfer" developed the following research questions to investigate during the project's first main phase:

- Which formats of academic and professional training are suitable for which target groups in order to best transfer concepts that merge the mobility and the energy transition?
- Which characteristics should the formats have and of which interdisciplinary components should they consist in order to best meet the demands of the industry and the development of innovative solutions?
- Which outreach formats are best suited to inform, sensitize, and increase acceptance for which target groups when it comes to fossil-free mobility?

[1] Mobility2Grid currently examines only the German energy and mobility sectors. A second main phase might also consider the potential for international transfer of project results.

The above-mentioned research questions are investigated in a pilot project using the following, mostly qualitative methods. Some quantitative methods with small case numbers also used:

- Analyzing target groups and their demands with explorative qualitative interviews, documentary and literature research, as well as workshops and case studies.
- Defining relevant characteristics/features for education formats, integrating different relevant disciplinary perspectives (ranging from technical foundations in energy engineering to transport, mobility, and planning basics and to social scientific questions of participation and acceptance) into a comprehensive interdisciplinary approach.
- Conceptualizing varying formats for academic, professional, and public target groups.
- Evaluating the offered formats as case studies with quantitative questionnaires.

Building on the results of the pre-phase, the "Education and Knowledge Transfer" working group is currently focused on the following educational formats and target groups, which will be described in the next sections:

- Formats for interdisciplinary academic education: Master's degree programs and summer schools highly relevant to the merging of the mobility and energy transitions; both formats are designed to reach domestic and international young professionals from business and administration and educate them as multipliers (see section 4.1).
- Formats for professional training: modularly designed, flexible, short-term training programs to transfer the idea of integrating electric vehicles in decentralized smart grids with renewable energies to different target groups in business, administration, education, and civil society (see section 4.2).
- Formats for knowledge transfer: Open symposiums to bring topics and results to the professional and public sphere; E-Schools[2], a format designed to bring knowledge to young pupils in schools (see section 4.3).

4. Preliminary results of testing formats for interdisciplinary education and knowledge transfer

4.1. Formats for interdisciplinary academic education

Two academic formats have been developed for the enhancement of knowledge about the integration of urban renewable energy production and electric mobility.

- Master's programs: Participation requires previous knowledge (like a bachelor's degree) on which interdisciplinary education can be based. As the master's programs are "weiterbildend", postgraduate job experience is required for admission. Thus, these programs are a combination of academic education and professional training and focus on young professionals who will introduce interdisciplinary knowledge into companies, industries, and the public sector. These programs are the focus of the academic formats.
- Summer Schools: Open formats that address an academically mixed target group, thereby allowing not only for interdisciplinary content but also for praxis-oriented modules.

Before the launch of Mobility2Grid, the TU-Campus EUREF (TUCE) at Technische Universität Berlin (TUB) developed four Master's programs covering three basic areas relevant to the energy transition to be held at the EUREF Campus: Energy-Efficient Construction and Operation of Buildings (ECOB); Energy-Efficient Urban Traffic Systems (EUTS); Municipal Infrastructure Management; and Energy Management (EM). All programs would take four semesters, culminate with the academic degree Master of Science (M.Sc.) from TUB, and were held entirely in German (with the exception of EM). They all integrated technical, economic, and social-scientific aspects and were designed for 30 students per year. However, despite a large investment in advertisement of the programs, application numbers were usually below 10 applicants per year and program. Following up with persons who were interested in the programs but eventually did not apply showed that a major factor dwarfing application numbers was the tuition fees of € 5,000 per semester.[3] Despite low application numbers, seven students were admitted to ECOB in 2012; that number increased to twelve students in 2013. The other programs did not admit any students. In 2013, TUCE joined the Mobility2Grid project consortium as an associated (unfunded) partner.

[2] The "E" can be understood as an abbreviation for both electric mobility and energy.

[3] For regular / consecutive Bachelor's and Master's programs at public universities, tuition fees are not allowed in Germany. Programs that are "weiterbildend" are, however, an exception because they are not included in the educative mandate public universities have and may therefore not make use of the public funding that allows for free education.

Subsequently, the Master's programs were redeveloped close to the project goals by integrating interdisciplinary theory and the practice of merging the mobility and the energy transition. Later that year, the Institut für Energie- und Regulierungsrecht e.V. (ENREG), an external association for energy and regulatory law, in cooperation with TUB and TUCE, established a Master's program in European and International Energy Law at the EUREF Campus. The program was held in English, lasted two semesters, and awarded the degree Master of Business Law. Due to comparatively high application numbers for the Energy Law program, internalization was considered and eventually decided upon also for the other Master's programs. In addition to the larger target group that English as the program language implied, it also included changing the degree from M.Sc. to Master of Business Administration (MBA). As the programs target young professionals, an MBA degree was more attractive to applicants who already had working experience compared to the rather research-focused M.Sc. Finally, the program redesign included the following decisions: reduction of technical contents, change of language and degree, and shortening of duration to three semesters (full-time studies) in order to facilitate a shorter stay for international students.

As it was already an English language program, the first program to be redesigned was EM, which re-opened in October 2015. The program received almost 200 applications for 30 available places. ECOB followed. Being the only program that had already had two cohorts, student feedback was also included in this redesign process. It resulted in the program "Building Sustainability – Management Methods for Energy Efficiency" (BS), which started in October 2016. EUTS gave way to "Sustainable Mobility Management" (SM), which will start in October 2017. SM development was partly driven in a participative way (see section 4.3). Previous years' experience shows that around 30–50 percent of admitted applicants start the program, so it can be assumed that around 10–15 students will start the new MBA in Fall 2017, comparable to the first cohort of EL and BS.

Table 1. Number of students in English-language Master's programs

		EL	EM	BS	SM
Cohorts started by Oct. 2017		4	3	2	1
Students in cohort…	2014	11	-	-	-
	2015	21	30	-	-
	2016	14	29	16	-
Applications for 2017		58	308	72	28

EL: Energy Law; EM = Energy Management; BS = Building Sustainability; SM = Sustainable Mobility Management

Table 1 shows the development numbers of students enrolled in the programs and the numbers of applications for the 2017 cohort, as enrollment is not yet complete by this paper's deadline. EM is clearly a highly successful program. For BS and SM, it is yet too early to draw conclusions, but they both show positive trends. Students come from countries inside and outside of Europe, with Germans making up only for a small fraction in each program.

Table 2 depicts program content and schedule of the SM MBA. Three things can be highlighted: First, despite a shorter study duration and reducing content, the modules are still highly interdisciplinary and include technical, economic, social-scientific, and ecological aspects. Second, even though this program is closest to Mobility2Grid, it is explicitly not a Master's program about electric mobility; rather, it is a broader program about sustainable options of mobility and transport management for the future as well as about the transition process.

Table 2. Program content MBA Sustainable Mobility Management.

Winter semester 1	Summer Semester	Winter semester 2
Project Management (9)	Mobility Trends and Futures (9)	Managing Smart and Green Mobility (6)
Technological Foundations in Transport (9)	Managing Transition: Governance and Skills (9)	Elective II (6)
Mobility Actors and Practices (6)	Lecture Series (6)	Master Thesis (18)
Macro-Economics and Business Models of Sustainable Mobility (6)	Elective I (6)	

In brackets: number of ECTS credit points for the respective module.

Program organization and administration were transferred from TUCE to another TUB subsidiary in Fall 2016. However, cooperation with Mobility2Grid remains in decisive areas. Researchers and professionals who are active in the project are engaged as lecturers and EUREF-Campus facilities is integrated into lectures when useful. Evaluations are conducted to secure the integration of project contents into the Master's programs.

The first evaluation specific to Mobility2Grid was conducted in the Building Sustainability program in Spring 2017. The questions were developed by the working group "Education and Knowledge Transfer" and integrated into a distinct section of the program's general online evaluation. The numbers showed that the general idea about the integration of the energy and the mobility system was subject of lectures, as table 3 shows.

Table 3. Evaluation questions and responses (n = 9)

Questions | Response options:	Yes	To some extent	No	Don't know
Was mobility transition discussed as part of the energy transition?	6	3	0	0
Has the integration of (electric) mobility into decentralized energy systems been the subject of your lectures?	5	5	0	0
Was it discussed how commercial and private electric vehicles can become part of an intelligent energy storage landscape (as on the EUREF-Campus)?	5	4	0	0
During the semester, did you perceive the EUREF-Campus as a physically real experimental laboratory for decentralized energy supply and mobility concepts?	4	2	2	1

Open response sections also pointed out that improvement is needed when it comes to using the EUREF Campus and the Micro Smart Grid site as a teaching object. Other students pointed to practical aspects and connections to hardware as aspects that should be strengthened.

Compared to the Master's programs, we have had less experience with the Summer Schools. The aim of this format is to reach out to students and young professionals from very different disciplines in order to reach a broader group than is targeted for the Master's programs. The target groups are not necessarily interested in becoming experts in merging the mobility and the energy transition, but want to learn about it in a compact and intensive format in order to integrate this knowledge into their professional competences. This program also leads to a broader dissemination of this information in the professional world. Since 2015, five Summer Schools have been conducted:

- 2015: "Energy Efficiency and Use of Renewable Energy in Urban Environments", 40 participants, 12 days
- 2016: a) "Ways of Development of the Energy Sector: Modern Challenges", 40 participants, 12 days
  b) "Sustainable Solutions in Electric Mobility for Berlin", 23 participants, 12 days
- 2017: a) "Best Practice for Electric Mobility in the Context of the Energy Transition", 33 participants", 10 days
  b) "Managing Innovations and Creating Innovative Business Models", 14 participants, 12 days

These Summer Schools were conducted in part by TUCE and in part by TUB departments active in the topic field "Education and Knowledge Transfer". The Summer Schools' participants' academic backgrounds were mixed, with a focus in different engineering disciplines (mechanical / energy / industrial / civil engineering). The target groups of the Summer Schools 2015 and 2016a. were students and young professionals from Germany and Russia. A strong focus was placed on excursions to sites that are relevant to the energy and mobility transitions. The 2015 program included a workshop about ideating for eco-innovation; the 2016 program allowed students to choose between three different practical workshops in energy engineering. Similarly, the other programs included workshops that connected the program practically to certain aspects of Mobility2Grid. The 2016b. Summer School asked, "How might we help the city of Berlin become a more sustainable city in terms of transportation?" The 2017a. program asked in its workshop sessions how to enhance the use of electric mobility solutions by families from Berlin and was organized in cooperation with the TUB alumni office for TUB alumni from Asian countries. The 2017b. workshop topic asked, "How might we build a blockchain based peer 2 peer platform that meets hearts & minds of [an energy company] customers?" The aim was to find ways for using blockchain technology for transacting and de-centrally dealing with excess renewable energy, i.e. from prosumer to consumer without

intermediaries. The workshops were the major method for facilitating interdisciplinary work. The feedback showed that the practical aspect of developing an idea into a product was especially appreciated.

4.2. Formats for professional training

Developing professional training programs for employees of companies and organizations active in the energy and mobility sector was added to the working group's agenda for the project's main phase. The groundwork was already laid in the pre-phase and the general concept features (compact, flexible, modular) were already set. Work during the main phase began therefore with a needs assessment, using a quantitative survey and two interviews. The aim was to find out about the specific needs of companies and organizations whose staff will increasingly have to deal with electric mobility and are thereby affected by the energy transition at large, for instance in areas like garbage disposal, city cleaning, or local transport. The survey was first designed on paper to be handed out at different events. Afterwards, it was also sent out to the mailing lists of partner organizations.[4] In the end, 11 organizations filled out surveys which could be used as a basis for developing the interview outline and as a basis for comparison with external studies, mostly Ministerium für Finanzen und Wirtschaft Baden-Württemberg et al. 2012, which is an analysis of the need for academic qualifications for sustainable mobility. In that study, representatives from 111 companies (mainly in the automotive industry and consulting) answered a comprehensive survey. In addition to general statistic data (work sector, organization size, position), our survey asked if:

- electric mobility was relevant in the company / organization (eight respondents said this was the case);
- the employer funds further training programs (seven cases);
- training programs in electric mobility exist (none agreed completely);
- training programs in this field were helpful (six agreed, but three disagreed completely).

While our survey focused on electric mobility, ibid. 2012 analyses the need for qualification in the broader field of sustainable mobility. In that study, 82.8 % of the respondents said that sustainable mobility will become very important for the sector and 73.8 % said it will be important for their company (ibid., p. 32). Our survey then asked about topics which would be relevant to the field. In accordance with the aforementioned study, the results show high interest in the area of battery systems and renewable energies / energy systems: In our survey, nine responses indicated that both cases were "predominantly interesting" or "very interesting", and around 90 % of the companies in ibid. 2012 (p. 37) said these fields were important for future qualification. Whereas 10 out of 11 survey respondents said charging stations were predominantly or very interesting in this field, around 80 % in ibid. 2012 saw charging management as important or very important. Innovative business models and trend determination were seen as interesting by eight respondents, in contrast to 60 % in the 2012 study that asked about planning and development of business models and concluded that demand in this field will grow in the long-term.

The interviews that followed the survey were conducted with representatives of a public transport organization and a school for vehicle-related vocational training, both partners of Mobility2Grid. The interviews aimed at finding out about the organization's current engagement in electric mobility, its qualification measures for employees, and relevant contents and characteristics of potential training programs. Regarding public transport, the results showed that trainings are most important at management level to get acquainted not only with electric mobility, but also with its broader context within the energy transition. For the school, the survey revealed a need to develop a basis for the pupils to be able to cope with electric vehicles when this technology becomes more popular. Electric mobility is of ever increasing importance and the most relevant contents will be battery management, energy supply, fuels cells, and connecting vehicles with their environment. Based on the results from the pre-phase, the survey, and the interviews, our working group developed the following six modules:

- M1: Mobility2Grid Basics
- M2: Renewable Energies and Smart Grids
- M3: Battery Systems
- M4: Electric Vehicles
- M5: Energy and Charging Infrastructure
- M6: Innovative Business Models

[4] The working group has no information about the mailing lists' size, therefore the number of people that were reached is unknown.

Each module can be taught in two to four hours. The minimum duration for a training program is four hours and the maximum is two days. This format takes into account the limited amount of time that employees are able to allocate to external qualifications. All modules include theoretical input and practical sessions (except for M1 which is purely informative about Mobility2Grid). Companies and organizations are thus free to choose their individual training programs and focus.

After having developed the modules, the next step was to test them with Mobility2Grid members. For the working group, this had the benefit of collecting feedback, learning, and making adaptions to the formats without going directly to an open and highly competitive market. Additionally, project member companies could benefit from training programs at no charge since costs for the pilot training programs were covered by the project funding. Preparations included detailed discussions with the organizations in order to find out about their desired focus and background knowledge, and to enable the addition of sector-relevant information to the modules. As a practical component, both training sessions included a visit to the EUREF-Campus's zeeMobase which is both showroom for and actual part of the campus Micro Smart Grid. The first training program was conducted in 2017 with one partner, teaching the modules M2 (four hours), M3 (two hours), M4 (two hours), and M5 (four hours) to four participants representing different management levels. The second training session was conducted with an external organization in the transport sector in 2017. This training session was with seven heads of department in the vehicle and fleet management sector and covered M3 and M5 (two hours each). Another training session with a different Mobility2Grid project member is planned early in 2018.

After the training session, all participants were asked to fill out an evaluation form that asked about positive aspects of the training, what the participant had learned, and what should be improved. Location, atmosphere, a good overview about the topics at stake, and the visit to zeeMobase were most commonly evaluated as positive. However, the educational outcome of the first training session was evaluated as being less positive, as participants described the contents as too generic for them as target group. They suggested improvements in the pre-consultation (asking each participant about their interest and existing knowledge in the topic instead of talking to one company representative) in order to be able to adapt better to the respective target group's topic focus. This was taken up for the second training. The general overview of topics was consistently named as positive in the second training session. Some participants saw this overview even as comprehensive, and in one case, as "in-depth." The practical examples were appreciated as well, even though both groups suggested giving more information about more specific know-how, especially with regard to where organizations stand in the mobility transition (good practice examples) and what needs to be done for realizing Mobility2Grid concepts in their companies. Whereas most participants wanted to know more about practical aspects such as costs and prognoses, one participant requested more information about future research and development projects. Like the different assessments of the content overview, which ranged from basic to in-depth, this discrepancy also shows the complexity of dealing with participants' diverse interests and levels of background knowledge.

4.3. Formats for knowledge transfer

The formats for knowledge transfer are designed to reach target groups that are not integrated in the Forschungscampus Mobility2Grid or the EUREF-Campus and usually only have limited or no connection to the topics. For knowledge transfer into civil society, the working group decided to host an open, annual symposium. Additionally, it decided to develop the "E-School" targeted at young pupils (ages 10–12).

The format "Mobility2Grid Symposium" was developed to transfer knowledge into both professional and public spheres and takes place once a year at the EUREF-Campus. Target groups include interested people from science and the public. They are invited with an online-published program flyer and via e-mail to mailing lists of partners. The number of participants is limited (60-70 persons) and participation is free. It focuses on another Mobility2Grid topic each year. The format combines lectures by project members and external experts, discussions, interaction in working groups, networking and informal exchange during lunch breaks, and a guided tour of the EUREF-Campus. Documentation of the symposium and its results is published online. The first Mobility2Grid-Symposium in 2016 was titled "Sustainable Mobility Management – Shaping the future of mobility management! Lehre für Mobilitätsplanung mitgestalten!" (Forschungscampus Mobility2Grid Ed. 2016). It focused on the conception of the new MBA "Sustainable Mobility Management" (see section 4.1). Participants were informed about the existing concept and received input from external experts. In small working groups, they then made recommendations on how to further develop the concept, which have since been integrated into the final concept. The second Mobility2Grid-Symposium (2017) was entitled "Acceptance and participation as preconditions for the energy and

mobility transition". About 60 people from different professional backgrounds in business, science, and interested civil society participated in both symposia. Participants in the symposium showed a willingness for information and discussion and for giving substantial recommendations. The next three symposia will take place in the years 2018 to 2020 and each focus on a different aspect of Mobility2Grid.

The format "E-School" aims at triggering interest for topics such as climate change, renewable energies, and electric mobility in pupils who are about to start high school. Because of the time and administrative process required to integrate new scientific knowledge into school curricula, the working group created this format as an opportunity to reach young pupils in a direct and uncomplicated way. The only requirement was to find an interested school that let pupils participate for one day. The format allows knowledge to be transferred independently of the school's set curriculum directly to pupils. It was designed didactically in a way that would appeal to pupils so that they would become interested in these topics and act as multipliers in their families. The first pilot E-School took place in late 2016, with one sixth grade class (pupils aged 10-12). The pupils were invited to the EUREF-Campus to learn about renewable energies, climate protection, and electric mobility. An instructor presented facts and experiments about climate change, the connection to energy production and consumption, and about actions for climate protection in their everyday lives. Afterwards, the pupils built their own model solar cars with playing bricks and let the cars have a race. They visited the zeeMobase where they learned about the elements and function of the Micro Smart Grid and, at the end of the day, rode in an electric car – a new experience for most of the pupils. The working group made a film about the day which can be watched online. The pilot E-School showed that the format is suitable to sparking interest for the energy and mobility transitions. The next E-School will take place in Fall 2017.

5. Preliminary response to research questions and next steps

We have developed and tested several different educational formats with the aim of reaching various target groups. In the course of this development, we have seen promising demand for Master's programs, indicating a desire for academic programs for young professionals with some job experience. The high application numbers for programs like the Energy Management MBA show that a broader program that includes technical and economic aspects is more attractive than more specialized programs. However, acceptance of and interest in these other programs might also increase as they become more established. To fulfil demand and help to transfer solutions that merge the energy and the mobility transitions into the practical concepts and products of business, the programs must have the following main characteristics: (1) They should be as short and flexible as possible to reach staff of companies that want further qualifications. (2) The content should be based in theory, but utilize a broad interdisciplinary and practical approach. (3) They must demonstrate how to merge the energy and the mobility transitions in a living lab setting. (4) The graduates should act as multipliers in the broader society.

Feedback regarding professional training programs confirms that while highly individualized modules are in demand, these are also difficult to organize due to the differing knowledge and backgrounds of training groups. It is therefore necessary to conduct thorough consultation in advance of the trainings and invite companies to send employees who share roughly a similar level of existing knowledge. Generally, businesses have valued the "compact" and "modular" characteristics of the training programs. Above all, the praxis oriented aspects of the training programs are highly valued. Building on this evaluation, further examples of good practice in the energy and mobility transition are to be added to the training programs. The symposium and the E-School seem to be suitable formats for transferring knowledge to very different target groups in the public sphere. While the symposium format lends itself well to parties that already are interested in the symposium's annually changing topic, the E-School helps raise interest in school children who did not have any connection to the topic before, thereby awaking interest in a new generation for these and related issues.

It remains to be seen which formats succeed in the long term. While the Master's programs are economically viable because of their tuition fees, the Mobility2Grid project contents need to be better integrated. The qualification training programs are, as of now, financially dependent on the ministry funding. The next step is therefore to adapt them to the feedback that was given so far and offer them on the free market so that they eventually will work without public funding or with a public/private funding option. The symposium and the E-School will inherently remain related to the project but depending on feedback and interest by schools, it might be interesting to find funding for broader application in order to reach more pupils and schools or to offer the format for free in different application areas that work with young people. As a next step, Forschungscampus

Mobility2Grid's "Education and Knowledge Transfer" working group plans to further implement and evaluate the different formats that have been described here. Cooperation with Mobility2Grid's other working groups will be further strengthened so that up-to-date project results will be included in all educational formats.

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