Contributions to Decision Support Systems, Energy Economics, and Shared Micromobility Research

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Abstract

This thesis includes research articles on Decision Support Systems, Energy Informatics, and Economics, Shared Micromobility, and Digital Study Assistance. For many years, established Information Systems (IS) scholars have called for solution-oriented research to address the most pressing problems of climate change. In this context, this thesis summarizes three consecutive research articles that present the multi-year development of a Decision Support System (DSS) for the energy transformation of the building sector. The DSS Nano Energy System Simulator (*NESSI*) was developed using Design Science Research guidelines and was further field tested and evaluated with stakeholders. In the discipline of Energy Informatics, a research article is presented that provides a morphological box for the classification of real microgrids. Next, a research article is presented that used regression analysis to investigate the influences of factors on residential photovoltaic system prices and revealed spatial price heterogeneity in Germany.
Three research articles are outlined in the Shared Micromobility field. The first article uses a multi-year dataset of location data to examine the spatial and temporal use of e-scooters in Berlin. The second article builds on this and quantifies the influences of various factors such as weather, Covid-19 lockdowns, and other socio-economic parameters on the use of three micromobility concepts. The third article uses a web content mining process to collect a large dataset of police reports on e-scooter accidents. It analyzes risk factors as well as accident implications for riders. A research article on the requirements analysis and development of a digital study assistant concludes this thesis. Here, quantitative surveys and qualitative expert interviews are used to collect requirements from higher education institution stakeholders for a digital study assistant. In addition, developing a study assistance prototype is demonstrated and tested in the field.

Keywords: Decision Support Systems, Design Science Research, Energy Economics, Energy Informatics, Shared Micromobility, Spatiotemporal Analyses, Accident Analysis, Digital Study Assistance

Research Summary

This dissertation includes nine research articles, eight of which have been accepted or published, and one is under peer review. The nine research articles can be assigned to three diverse thematic clusters. The first cluster comprises the research disciplines of environmental decision support systems (DSS) in Information Systems (IS) Research, Energy Informatics, and Economics. The second cluster includes three research articles that investigate the temporal and spatial usage of micromobility and analyze the safety of e-scooter traffic. The third thematic cluster includes only one research article on digital study assistance. Table 1 provides an overview of all research articles, their association with a research domain, and the corresponding section.

Table 1: Research domains, sections, and research article titles.

Domains	**Section**	**Research Article Titles**
Decision Support Systems, Energy Informatics, and Energy Economics	2.1	Decision Support for Optimal Investments in Building Energy Systems
	2.2	Transformation to Sustainable Building Energy Systems: A Decision Support System
	2.3	Open Access Decision Support for Sustainable Buildings and Neighborhoods: The Energy System Simulator NESSI
	2.4	Classification of Real-World Microgrids Based on a Morphological Analysis
	2.5	Disentangle the Price Dispersion of Residential Solar Photovoltaic Systems: Evidence from Germany
Shared Micromobility Usage and Safety	3.1	A Spatiotemporal Study and Location-Specific Trip Pattern Categorization of Shared E-Scooter Usage
	3.2	Factors Influencing the Usage of Shared Micromobility: Implications from Berlin
	3.3	Web Content Mining Analysis of E-Scooter Crash Causes and Implications in Germany
Digital Study Assistance	4	User-centric Design, Development, and Evaluation of an Individual Digital Study Assistant for Higher Education Institutions

The following briefly describes the motivation and relevance of environmental DSS in IS research, Energy Informatics, and Economics. The 17 Sustainability Development Goals (SDGs) of the United Nations (UN) and the Paris Agreement of 2015

outline directives to mitigate the effects of global climate change. One of the key objectives is to drastically reduce CO_2 emissions across all sectors, such as energy supply, transport, and building and construction. The energy supply of buildings accounts for 30% of global energy consumption. In addition, building operations account for 27% of total energy sector emissions [1]. Thus, the transformation of the building sector holds immense potential for reducing global CO_2 emissions. Policymakers can accelerate this transformation through targeted measures, such as feed-in tariffs for renewable energy technology or subsidy programs for heat pumps. However, building decision-makers are responsible for making investment decisions. The development of DSS has a long tradition in the IS community [2]. With the emergence of Green IS and Energy Informatics, IS-induced DSS that address climate change issues are becoming more prominent [3]. Established IS researchers have been calling for years to leverage the transformative power of the IS discipline and provide solution-oriented artifacts for complex decision-making to tackle climate change [4, 5]. Research articles 2.1 to 2.3 present the development of the DSS *NESSI* (Nano Energy System Simulator) within a Design Science Research (DSR) project of more than four years. Its final version is designed to support decision-makers like residential and commercial building owners, housing associations, and energy consultants in transforming buildings to an emission-free energy supply.

2.1 Decision Support for Optimal Investments in Building Energy Systems

The first research article emerging from the *NESSI* DSR project initially addressed residential and commercial prosumers. Building owners who feed in electricity through renewable energy technologies are referred to as prosumers in academic literature [6]. The Renewable Energy Sources Act (EEG) has supported the feed-in of electricity from renewable sources in Germany since 2000. The steadily falling feed-in remuneration and dynamic price development of energy technologies have complicated the decision-making basis for prosumers. Two key issues have been identified for prosumers: (i) rooftop photovoltaic (PV) systems installed before 2000 will fall out of the remuneration scheme, and the question arises about the further operation and possibly the coupling with other components. (ii) a large share of system owners must increase the self-consumption of their PV systems, and the question arises as to how this goal can be achieved efficiently from an

economic point of view.

In the context of a DSR approach according to [7, 8], a MATLAB-based artifact for prosumer decision support is proposed. It addresses the question of how incremental investments optimally enhance building energy systems' efficiency? The artifact includes an energy system model that can simulate the operational management of various energy technology components at hourly time resolution over a year. The technical parameters used to model PV systems, battery power storage, hot water storage, heat pumps, and electric cars are outlined. Performance monitoring reports various key performance indicators (KPIs) such as degree of self-consumption, degree of autarky, and energy cost reduction.

A computational study demonstrates the applicability of the decision support artifact. As shown in Figure 1, the impact of incremental investments in PV systems, battery storage, and hot water storage on energy cost reduction can be quantified. Furthermore, the change in KPIs is shown to provide a more robust basis for decision-making.

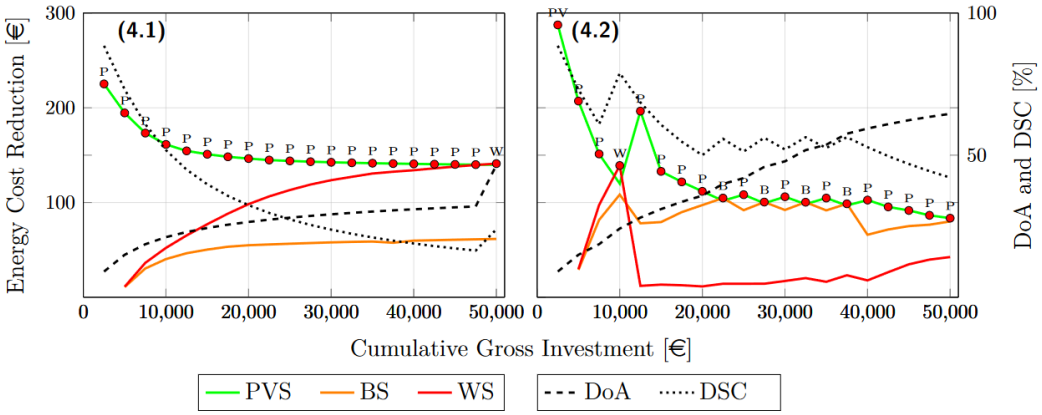

Figure 1: Overview of energy cost reduction for a four-person household.

The artifact architecture, underlying energy system model, and performance monitoring provide the foundation for further development into a comprehensive DSS. Research articles 2.2 and 2.3 build on the groundwork and core ideas of this article.

2.2 Transformation to Sustainable Building Energy Systems: A Decision Support System

Stemming from the prosumer focus, research article 2.1 generalized the problem formulation and opened it up to more stakeholders. Instead of the local reference to Germany, the global problem of the sustainable transformation of the building

sector was defined as the DSR entry point. Residential and commercial building owners, housing associations, and energy consultants must be supported in transforming buildings toward an emission-free energy supply. Addressing this problem, the user-centered and solution-oriented DSS *NESSI* is proposed according to the DSR publication scheme of [9]. The development process was embedded in the three-cycle view of [10].

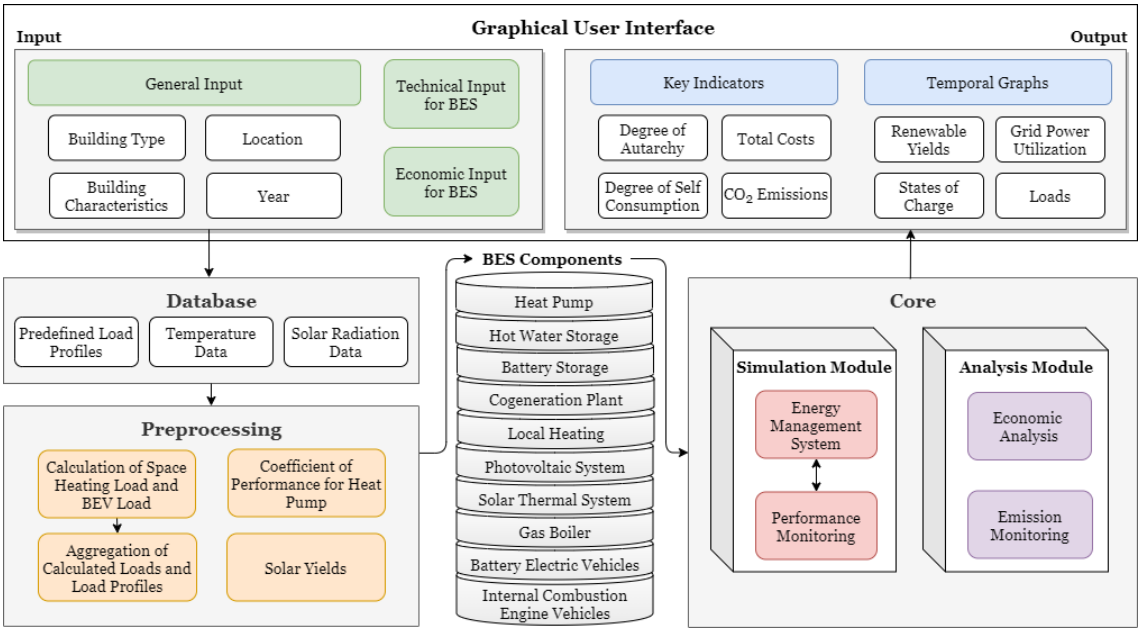

Figure 2: System Architecture of *NESSI*.

NESSI's overall MATLAB-based system architecture is presented in Figure 2. It includes the graphical user interface (GUI) structure, the underlying database with load profiles and weather time series, the eligible energy system components, and the simulation and analysis kernel. As demonstrated by the GUI structure, the user can customize the building type, location, characteristics, and base year. Based on these inputs, the pre-processing can calculate further input parameters such as the thermal load profile, solar yields, and the heat pump's coefficient of performance (COP). These input parameters and time series are, in turn, used for yearly energy system simulation in hourly resolution. The portfolio of energy technologies has been significantly expanded compared to the prior work in research article 2.1. *NESSI's* applicability and validity are demonstrated with a computational study. In this study, a detached family house and office building in Hanover are simulated based on real data, and subsequently, 26 energy system configurations are evaluated economically and ecologically. Moreover, the publication of 2.1

and a prior presentation of *NESSI* at the pre-ICIS SIG Green workshop in 2019 were conducted as evaluation steps.

2.3 Open Access Decision Support for Sustainable Buildings and Neighborhoods: The Energy System Simulator NESSI

The research article 2.3 outlines the most mature version of *NESSI*. Through further iterations of [8]'s DSR process, significant enhancements have been incorporated into the overall DSS. *NESSI* has been completely migrated from MATLAB to the Python programming language, which has led to the deployment of *NESSI* as a web tool. The entire DSR-guided process is again presented using [9]'s publication scheme. *NESSI's* final software architecture is outlined in Figure 13.

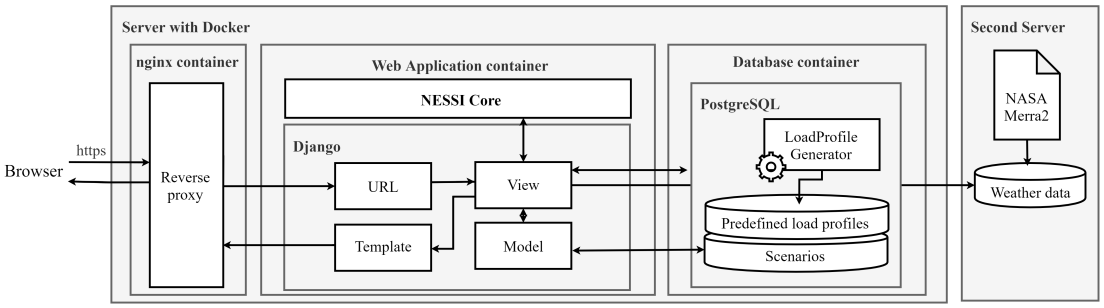

Figure 3: Final Software Architecture of *NESSI*.

Stakeholder, model, and system-oriented objectives were derived from a literature review of energy system models and a comparison with related computer tools. Current literature reviews (e.g., [11, 12]) confirm that open access release and out-of-the-box functionality are important tool characteristics. Based on an in-depth artifact description, the software architecture, the simulation procedure, including the rule-based energy flow model, and a demonstration of user flow are elaborated. Furthermore, measures for the evaluation (e.g., expert interviews, presentations on public events) of *NESSI* are presented, and their influence on the development process is disclosed.

As energy systems become more decentralized and the number of distributed energy resources (DERs) increases, microgrids have emerged. Microgrids represent a promising solution to operate many DERs with Information and Communication Technology (ICT) securely and efficiently in a network. In this context, academic literature is used to develop a morphological box in research article 2.4, which can be used to categorize microgrids.

2.4 Classification of Real-World Microgrids Based on a Morphological Analysis

Although a few research papers on MG design exist (e.g., [13, 14]), the literature regarding the classification of microgrids (MGs) and successfully implemented MG projects is limited. Based on methodologies of [15–17], a systematic and keyword-based literature search to identify MG design literature was conducted. After performing backward, forward, author, and *Google Scholar* similarity searches, 36 research articles were consolidated. The procedure of the subsequent morphological analysis is based on [18]. The resulting morphological box encompasses five layers, 18 dimensions, 60 characteristics. An in-depth description of the five layers, including an explanation of which characteristics were derived from which reference, is provided.

The morphological box is utilized to classify 30 real-world MG projects based on a literature search of real-world MGs. The 30 MG projects are divided into four campus-related, seven commercial- and industrial-related, eight community- and utility-related , three military, and eight remote MGs. The MG projects are spatially divided among the following continents: twelve in North America, three in South America, four in Asia, six in Europe, three in Africa, one in Australia, and one in Antarctica. Each MG was assigned a maximum of one characteristic in one dimension to adhere to the rationale of the morphological box. The morphological box can be utilized by stakeholders and decision-makers to either classify existing MGs or derive requirements for new MG projects.

In Energy Economics, one of the interesting issues is how the prices of renewable energy technologies evolve and market prices emerge. Based on a comprehensive dataset of photovoltaic system quotes, regression analyses are conducted that quantify the effects of various factors on rooftop PV system prices in research article 2.5.

2.5 Disentangle the Price Dispersion of Residential Solar Photovoltaic Systems: Evidence from Germany

Although Germany has a large and mature roof PV market compared to other European countries, it is challenging for many homeowners to evaluate whether they received a fair quote. There needs to be more price transparency in the market. Furthermore, from the perspective of policymakers, it is relevant to understand which factors must be addressed to establish reasonable PV system prices and thus

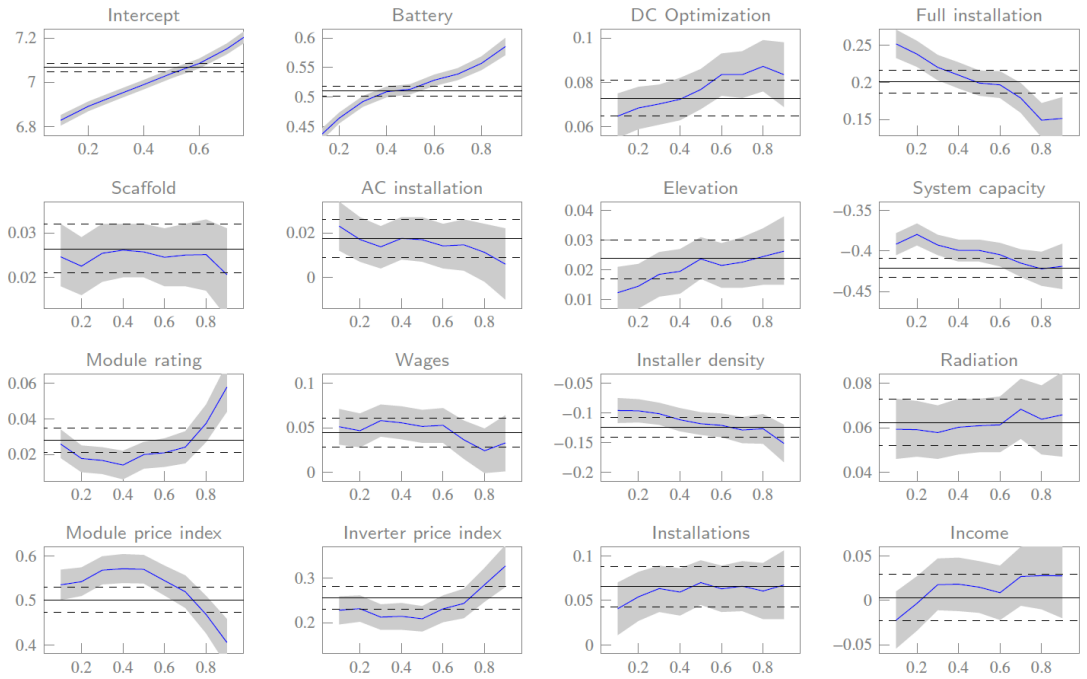

Figure 4: OLS (REF) estimates (continuous horizontal line) with respective CIs as dashed lines, quantile regression estimates (blue line), with respective 95 % CIs as shaded gray area.

amplify installations. Related studies on the decomposition of PV system prices have been conducted mainly in the United States (U.S.). [19] provided results on the deconstruction of solar PV pricing. [20] and [21] have investigated factors that affect low-priced PV systems, in particular, and the associated characteristics of those systems. Moreover, [22] and [23] have emphasized the importance of price transparency in residential PV markets and the effects of PV installer market concentration on system prices.

A web-mining approach collected 19, 208 PV system quotes from January 2011 to May 2022. The quotes comprised additional information about postal zip code, module and inverter characteristics, and further system attributes. This PV system quote dataset was enriched with features such as module efficiency or inverter power rating. The dataset is used to reveal geographic price heterogeneity in Germany in two-digit zip code resolution. Based on Hedonic price modeling, two linear ordinary least square (OLS) regression models are defined. One represents the reference model (REF), and the other incorporates geographically dependent variables as fixed effects. In addition, quantile regression is performed for five quantiles (PV price classes). Within the quantile regression, the effect sizes of 15

independent variables are quantified on five price quantiles. The effect sizes are shown in Figure 4 for each independent variable.

Shared Micromobility Usage and Safety

Profound changes are on the horizon in future urban transportation. Digital transformation and growing electric mobility have led to the widespread dissemination of shared mobility concepts in cities worldwide. Shared bicycles (bikes), electric scooters (e-scooters), and electric mopeds (e-mopeds) are the most common concepts. The emergence of these new transportation concepts poses significant challenges for cities. Adequate regulatory frameworks must be designed so that micromobility concepts can find a place in cities despite the scarcity of traffic space. Articles 3.1 and 3.2 analyze the temporal and spatial use of micromobility based on large location datasets. Article 3.3 investigates the causes of e-scooter accidents and derives implications for the ridership's safety.

3.1 A Spatiotemporal Study and Location-Specific Trip Pattern Categorization of Shared E-Scooter Usage

Within nine months, around 4.2 million raw e-scooter trips were collected. Using comprehensive filter criteria related to travel time, average velocity, detour factor, and distance, the raw dataset was significantly reduced and consolidated to 1.25 million e-scooter trips. Four different trip types were identified by further filtering criteria related to haversine distance, energy consumption per trip, battery level deviation, and trip distance. User trips include one-way and round trips. Operator trips comprise charging and re-allocation trips.

The four trip types were examined for temporal usage patterns. Weekdays and weekend days were considered separately. One-way user trips increased in the morning between 7 and 9 a.m. on weekdays, suggesting work-related commuter trips. By far, the highest volume of user trips is in the afternoon on weekends. These weekend trips also had the longest average travel distance at about 2000 m. The temporal patterns revealed that charging trips predominantly occur in the evenings from 10 p.m. until late at night. Trips for re-allocating e-scooters were increasingly carried out between 7 and 9 a.m. and in the evening from 10 p.m. onwards.

The trip dataset was divided into origins and destinations to enrich the temporal analyses with geographic features. The five different land use types, residential,

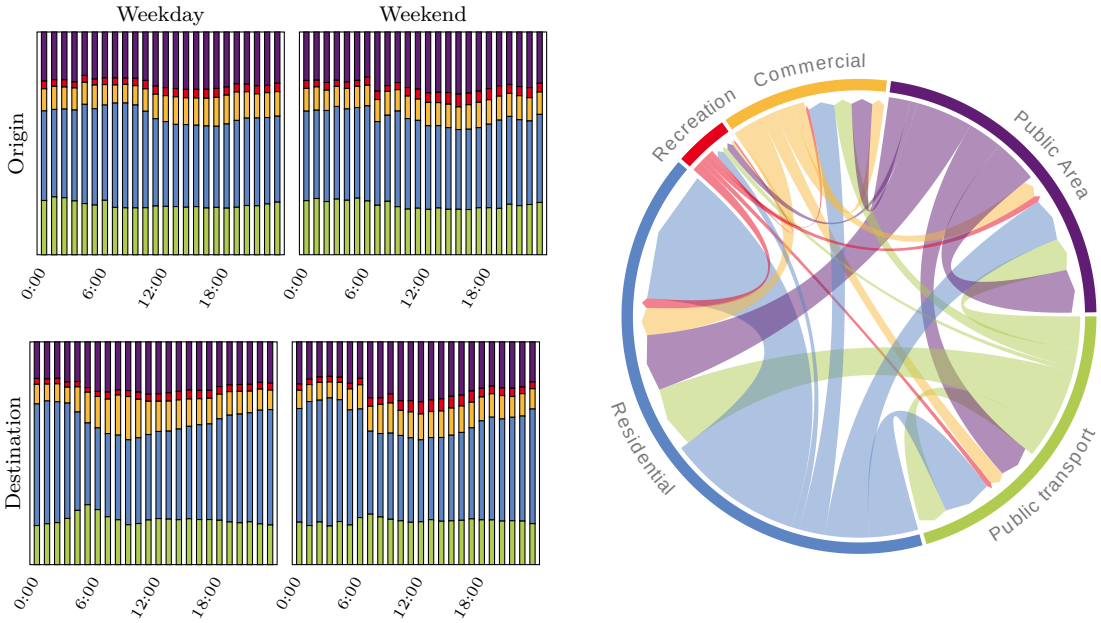

Figure 5: Temporal land use distribution of trip origins and destinations (left) and the corresponding connection in a chord diagram (right).

commercial, recreational, public, and public transport, were assigned to the origins and destinations. Figure 18 shows the temporal progression of origins and destinations per land use type. Moreover, origin-destination pairs are visualized as trip flows among land use types.

The influence of the built environment on origins and destinations is demonstrated using hierarchical and density-based spatial clustering with noise (HDBSCAN) algorithm. In addition, characteristic temporal usage patterns are revealed for various public transport-, sights- and commercial area-related points of interest (POI). The results on the spatiotemporal usage of e-scooters in Berlin can be used by urban and transportation planners and e-scooter operators for improved traffic flow planning and more efficient e-scooter deployment. The POI-resolved results enable urban planners in particular to take location-based measures.

3.2 Factors Influencing the Usage of Shared Micromobility: Implications from Berlin

This research article draws on a trip dataset of shared bicycles, e-scooters, and e-mopeds in Berlin from September 2019 to March 2022. It extended the single-mode investigation of research article 3.1 and increased the dataset's scope. The start and end points of the approximately 8.5 million micromobility trips were spatially

Figure 6: The percentage changes in trip counts associated with predominant land uses in a TAZ.

resolved to 542 traffic analysis zones (TAZs), creating a panel dataset. The Senate Department provides the TAZs for Urban Development, Building, and Living of Berlin. The TAZs have additional information about population density, tourists per day, gender, age distribution, and welfare recipients. Similar to research article 3.1, thirteen different land use types were used to geographically categorize trip origins and destinations. To quantify weather effects on micromobility trips, time series of air temperature, sunshine duration, humidity, precipitation, and wind speed from four weather stations were assigned to trips. Furthermore, temporal variables such as day of the week, weekends, time of day, Covid-19 lockdown periods, and dominant land use type per TAZ were added as categorical variables to the dataset.

Descriptive analysis of the dataset included temporal usage patterns and fleet size developments. The e-scooter-related temporal usage pattern of 3.1 was confirmed. Shared bicycles and e-mopeds showed a similar pattern. However, the trip volume of these two modes is significantly lower on weekdays between 10 a.m. and 4 p.m. Consideration of fleet size developments showed significant increases in vehicle numbers for all modes.

A negative binomial (NB) regression model was defined to quantify the influences of various factors on micromobility usage. The hourly trip volume of the three modes represents the variable to be described. The NB regression results indicated

that precipitation has the most negative effect of all weather variables. Covid-19 lockdown periods generally had a negative impact on trip volumes of the three modes, but e-mopeds were least affected. The effects of the thirteen land use types on mode usage are presented in Figure 6.
Core areas include commercial enterprises, central institutions of the economy, administration, and culture in TAZs. This land use type has a significantly positive effect on e-mopeds and e-scooters. In contrast, parks have the most positive effect on shared bicycle use. Overall, the results of this research article provide evidence that growing fleet sizes do not lead to proportionally more trips due to competitive effects. Effects associated with the thirteen land use types can enable operators for more efficient demand-based planning. Policymakers and operators can optimize sharing mobility services and facilitate evidence-based strategies for the spatial and temporal design of micromobility.

3.3 Web Content Mining Analysis of E-Scooter Crash Causes and Implications in Germany

The widespread use of e-scooters entails an increased risk of accidents and crashes. In addition to many clinical studies, one accident analysis with data sources like newspaper mining has been published in the U.S. [24]. Concerning Germany, the Federal Statistical Office has confirmed that the number of accidents involving e-scooters has doubled from 2020 to 2021 [25]. Due to the young history of e-scooters, few accessible data exist on e-scooter accident causes and outcomes in micromobility research. Therefore, a web content mining process (e.g., [26]) was developed to automatically collect and analyze $1,936$ police reports on e-scooter accidents. First, a systematic keyword-based literature search to consolidate the current state of research in accident analysis in micromobility was conducted.
The complete research design included conducting a systematic web content mining process (e.g., [26]) followed by sentiment and network analyses and visualization using a clustering algorithm. *Python*-based sentiment analysis was employed to assess objectivity in police reporting [27]. In comparison, network analysis was used to display graphical relationships from the most relevant keywords in the police reports. For this purpose, the open-source graph software *Gephi* was applied using *ForceAtlas2* and *Louvain* algorithms to create a network with communities [28, 29].
The resulting network with the 46 most important keywords is shown in Fig-

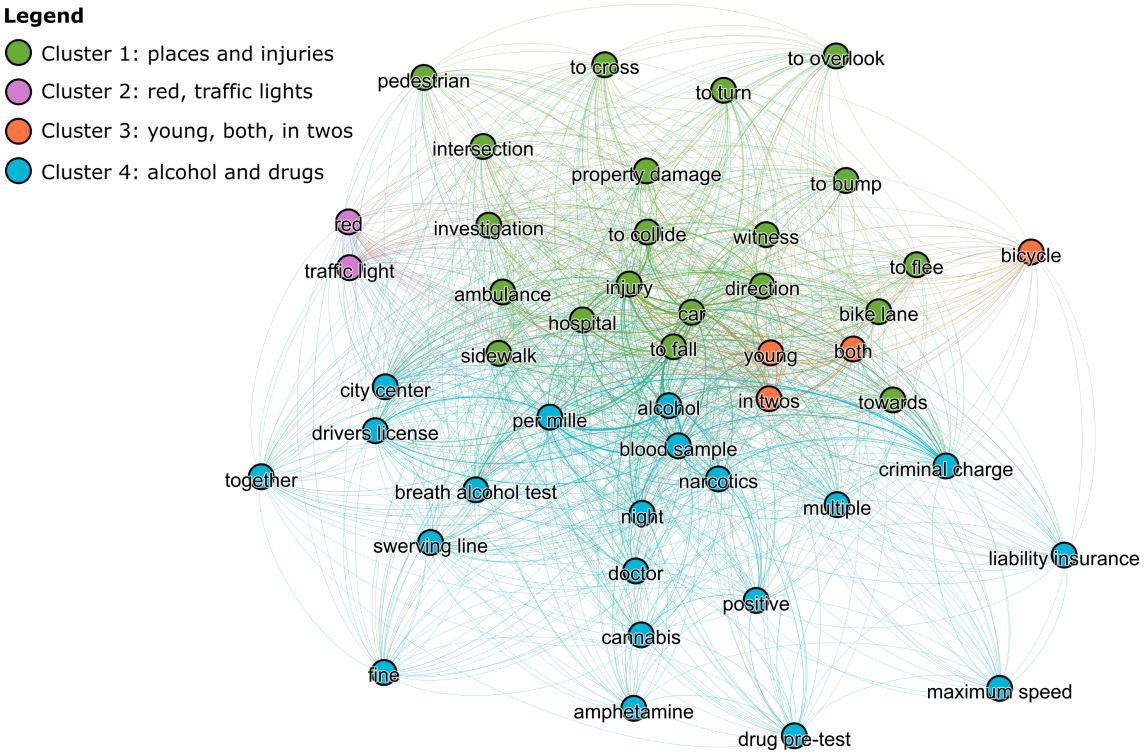

Figure 7: Network graph of 46 keywords and four communities visualized with *Gephi* using *ForceAtlas2* and Louvain algorithm [28].

ure 25. The four clusters were used to discuss accident causes and implications. In addition, five recommendations for improved safety for e-scooter ridership were proposed. Sentiment analysis confirmed objective reporting, as the polarity value was approaching zero.

4 User-centric Design, Development, and Evaluation of an Individual Digital Study Assistant for Higher Education Institutions

The number of lecturers and administrators has stagnated in recent years, while the student population has continued to grow and new academic programs have been developed [30]. Thus, a need for first, second, and third-level support for students at higher education institutions (HEIs) has arisen. This trend has intensified, especially during the Covid-19 pandemic. Consequently, characteristics such as intrinsic motivation, self-organization, and self-regulation have become even more significant for the successful course of studies [31].

However, acquiring these characteristics is perceived as demanding and challenging by students [32]. Additionally, [31] confirmed that a high degree of self-regulation

competencies positively influences HEI graduation. Starting from this problem, digital study assistants can address the lack of support options and thus enable students to succeed. Individual digital study assistants (IDSA) address these challenges with online, easy, ubiquitous, and automated access. Guided by Action Design Research, an IDSA that, e.g., improves students' self-regulation competencies, study goals achievement, and study organization were designed, developed, and evaluated in the field.

Based on 28 qualitative HEI expert interviews, a quantitative survey with 570 students, and a literature review, we first derive general IDSA requirements. User-centered, we then develop and evaluate our IDSA prototype tested by more than 1000 students. It, e.g., recommends lectures based on individual interests and competencies, offers matches with other students, or gives feedback about learning behavior strengths and weaknesses and can partly replace or supplement human first-level support. The IDSA requirements offer HEI administrative and lecturers practical knowledge and recommendations, support IDSA theory building, and reveal further research needs.

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Overview of Publications and Task Allocations

As summarized in Table 2, the underlying publications of this dissertation are classified based on the metrics of *German Academic Association for Business Research* (VHB) (e.g., [33]), the impact factor (IF), and *SCImago Journal & Country Ranks* (SJR) in 2021 (e.g., [34]). SJR metrics divide journals into quartiles in their associated research areas. If a journal is rated $Q1$, it belongs to the top 25% of all journals in that research area [35]. IF data is based on metrics provided by the journals' homepages. In general, the IF measures the average citations received in a given year by articles published in a defined previous period. Journals from *Elsevier* indicate the two-year IF. It is defined as follows: "The Impact Factor measures the average number of citations received in a particular year by papers published in the journal during the two preceding years" [36]. All published and submitted research articles of this dissertation were and are subject to peer-review processes. Additionally, for each article, the task allocation of authors is explained in detail.

Tobias Kraschewski and I have published the completed research paper *Decision Support for Optimal Investments in Building Energy Systems* on 25^{th} Americas' Conference on Information Systems in Cancun, Mexico. It represents one of North America's leading and established annual conferences on IS research. We have equally elaborated the idea and storyline of the article. I wrote large parts of the Introduction, Research Background and Design, and Artifact Description. Furthermore, I helped to design the Case Study and discuss the results. Tobias Kraschewski wrote significant parts of the Artifact Description, the Case Study, and the result interpretation. Michael H. Breitner has sharpened the article through discussion contributions and feedback. I presented our research article on AMCIS in August 2019 in Cancun, Mexico.

Tobias Kraschewski, Sarah Eckhoff, Michael H. Breitner, and I have published the completed research article *Transformation to Sustainable Building Energy Systems: A Decision Support System* on the 41^{st} International Conference on Information Systems (ICIS) which was conducted online. According to the Association for Information Systems (AIS) the ICIS is the most prestigious IS conference worldwide. All authors contributed equally to the idea and storyline of the research article. I wrote large parts of the Introduction, Theoretical Background and Related Re-

search, and Research Design. Additionally, I helped to conceptualize the Computational Study and results discussion. Tobias Kraschewski had the overall project lead and wrote significant parts of the DSS Description, Computational Study, and Discussion and Recommendations. Sarah Eckhoff was primarily responsible for the DSS development. She wrote the DSS Description and contributed to the Computational Study, Discussion, and Recommendations. Michael H. Breitner was a discussant and contributed to the final research article. Tobias Kraschewski presented our research article virtually on 41^{st} ICIS in 2020.

The completed research paper *Classification of Real-World Microgrids Based on a Morphological Analysis* was published at the 27^{th} AMCIS in Montreal, Canada, by Jana Gerlach, Sarah Eckhoff, Oliver Werth, Tobias Kraschewski, Michael H. Breitner and myself. Jana Gerlach and Sarah Eckhoff wrote the main parts of the paper, conducted the literature searches, and categorized real-world MG projects. Oliver Werth wrote the methodology section. I helped conceptualize the morphological box's layers, dimensions, and characteristics. All authors contributed to the discussion of results and overall editing. Michael H. Breitner was a discussant and contributed to the article's final version. Jana Gerlach presented our article virtually at the 27^{th} AMCIS in 2021.

Maximilian Heumann, Tobias Kraschewski, Lukas Tilch, Michael H. Breitner, and I have published the full-length article *A Spatiotemporal Study and Location-Specific Trip Pattern Categorization of Shared E-Scooter Usage* in the journal Sustainability in November 2021. The journal has a five-year IF of 4.09 [37]. According to SJR metrics, the journal is ranked as $Q1$ in Geography, Planning, and Development, and $Q2$ in Environmental Sciences [38]. The authors' contributions can be found in the publication. Specifically, I wrote large parts of the Introduction, conducted the Literature Review, developed and supported the data filtering, and conceptualized and interpreted temporal and spatial analyses. Michael H. Breitner was a discussant and contributed to the final research article.

Maximilian Heumann, Tobias Kraschewski, Oliver Prahlow, Jan Rehse, Christian Kiehne, Michael H. Breitner, and I have published the full-length article *Web Content Mining Analysis of E-Scooter Crash Causes and Implications in Germany* in the journal Accident Analysis & Prevention in December 2022. This journal has a two-year IF of 6.38 [39]. According to SJR, it is among the best five journals

in the subject area of Safety, Risk, Reliability, and Quality. Moreover, it ranks as the second-best journal worldwide in the subject area of Human Factors and Ergonomics [40]. As the first author, I conceptualized the idea of the article and performed the overall project supervision. I wrote large parts of the Introduction, Data and Research Methods, Discussion, and Results. Maximilian Heumann and Tobias Kraschewski supervised the data analyses and contributed to the result interpretation and editing. Oliver Prahlow wrote large parts of the Literature Review. Jan Rehse wrote large parts of the Discussion and contributed to the visualization of results. Christian Kiehne contributed to the data collection. Michael H. Breitner was a discussant and contributed to the final research article.

Furthermore, Maximilian Heumann, Tobias Kraschewski, Lukas Tilch, Michael H. Breitner, and I have submitted the article *Factors influencing the usage of shared micromobility: Implications from Berlin* to the *Journal of Transport Geography* with a current two-year IF of 5.89 [41]. This article is currently under review for the second time after major revisions. SJR metrics indicate that it is a Q1 journal in the areas of Transportation and Environmental Sciences [42]. I contributed mainly to the Data and Methodological Approach and Results and Discussion in writing the paper. Maximilian Heumann supervised the project and wrote the main parts of the paper. Tobias Kraschewski contributed to the Data and Methodological Approach and wrote parts of the Discussion and Results. Lukas Tilch contributed to the data collection. Michael H. Breitner was a discussant and contributed to the final research article.

Christin Karrenbauer, Claudia M. König, Michael H. Breitner, and I have written the full-length article *User-centric design, development, and evaluation of an individual digital study assistant for higher education institutions* and submitted it to the journal *Educational Technology Research and Development*. It has a current IF of 5.58 [43]. According to SJR metrics, it is a Q1 journal in the area of Education [44]. The article was under review at the time of submission of this dissertation. The article has since been accepted and has been published since June 2023. I was primarily responsible for the Prototype Development and wrote large parts of the Discussion, Implications, and Recommendations. Christin Karrenbauer supervised the project and wrote large parts of the Introduction, Results and Findings, and Conclusions. Claudia M. König wrote significant parts of the Theoretical Background and Research Design and Methods. Michael H. Breitner

was a discussant and contributed to the final research article.

Tobias Kraschewski, Maximilian Heumann, Michael H. Breitner, and I have submitted the full-length article *Disentangle Influencing Factors of Residential Photovoltaic Price Dispersion* to the journal Energy Economics with a current two-year IF of 9.25 [45]. According to SJR, it is ranked as $Q1$ journal in Economics and Econometrics, and Energy [46]. I wrote parts of the Results, and Discussion, Introduction and contributed to the data processing and analyses. Tobias Kraschewski supervised the project and wrote the main parts of the paper. Maximilian Heumann also wrote parts of the Discussion and Results and contributed to the data collection and processing. Michael H. Breitner was a discussant and contributed to the final research article.

Sarah Eckhoff, Maria C. G. Hart, Tobias Kraschewski, Maximilian Heumann, Michael H. Breitner, and I have submitted the full-length article *Open Access Decision Support for Sustainable Buildings and Neighborhoods: The Energy System Simulator NESSI* to the journal *Building and Environment*. It has a current two-year IF of 7.09 [47]. SJR metrics rank this journal as $Q1$ in areas Building and Construction and Environmental Engineering [48]. I wrote large parts of the Evaluation and contributed to the Introduction and Literature Review. Sarah Eckhoff had the overall project lead and wrote large parts of the Artifact Description and Research Design. Maria C. G. Hart wrote large parts of the Introduction, Literature Review, and Discussion. Tobias Kraschewski and Maximilian Heumann supervised the overall article and contributed to some sections. Michael H. Breitner was a discussant and contributed to the final research article.

Table 2: Overview of Publications and Submissions Under Review.

#	Status	Title	Authors	Journal & Conference	VHB[1]	IF[2]	Appendix
9	04/2023	Open Access Decision Support for Sustainable Buildings and Neighborhoods: The Energy System Simulator NESSI	Eckhoff, S., Hart, M.C.G., Brauner, T., Kraschewski, T., Heumann, M., Breitner, M.H.	Building and Environment	-	7.09	A.9
8	04/2023	Disentangle the Price Dispersion of Residential Solar Photovoltaic Systems: Evidence from Germany	Kraschewski, T., Brauner, T., Heumann, M., Breitner, M.H.	Energy Economics	B	9.25	A.8
7	06/2023	User-centric design, development, and evaluation of an individual digital study assistant for higher education institutions	Karrenbauer, C.; Brauner, T.; König, C.M.; Breitner, M.H.	Educational Technology Research and Development	-	5.58	A.7
6	Under Review	Factors influencing the usage of shared micromobility: Implications from Berlin	Heumann, M.; Brauner, T.; Kraschewski, T.; Tilch, L.; Breitner, M.H.	Journal of Transport Geography	-	5.89	A.6
5	12/2022	Web Content Mining Analysis of E-Scooter Crash Causes and Implications in Germany	Brauner, T.; Heumann, M.; Kraschewski, T.; Rehse, J.; Prahlow, O.; Kiehne, C.; Breitner, M.H.	Accident Analysis & Prevention	-	6.38	A.5
4	11/2021	A Spatiotemporal Study and Location-Specific Trip Pattern Categorization of Shared E-Scooter Usage	Heumann, M.; Kraschewski T.; Brauner, T.; Tilch L.; Breitner, M.H.	Sustainability	C	3.89	A.4
3	08/2021	Classification of Real-World Microgrids Based on a Morphological Analysis	Gerlach, J.; Eckhoff S.; Werth O.; Kraschewski T.; Brauner T.; Breitner M. H.	Proceedings of the 27th Americas Conference on Information Systems (AMCIS) 2021, Montreal (Canada)	D	-	A.3
2	12/2020	Transformation to Sustainable Building Energy Systems: A Decision Support System	Kraschewski, T.; Brauner, T.; Eckhoff, S.; Breitner, M.H.	Proceedings of the 41st International Conference on Information Systems (ICIS) 2021, Hyderabad (India)	A	-	A.2
1	08/2019	Decision Support for Optimal Investments in Building Energy Systems	Brauner, T; Kraschewski, T.	Proceedings of the 25th Americas Conference on Information Systems (AMCIS) 2019, Cancun (Mexico)	D		A.1

[1] based on [33] [2] based on journals' homepages and [36]