E-Mobility Research Network

Prof. Dr.-Ing. Dietmar Göhlich
E-Mobility Research Network

The multidisplinary reasearch network on e-mobility at the TU Berlin covers the entire value chain of electric transportation including cars, buses, and commercial vehicles. The participating 24 chairs from all seven schools of our university are equally active in fundamental and applied research.

The research projects extend from electric energy storage, electric drive trains and innovative components to innovative vehicle and manufacturing concepts but they also comprise the charging infrastructure and the grid integration as well as new intermodal transport systems.

The network provides a platform for joint projects, it strengthens the cooperation among Germany and international partner universities and it invigorates the collaboration with public and private institutions.
Research Area
Energy Storage and Conversion
Chemical Engineering, Electrochemical Catalysis

E-Mobility Research Interests and Competencies

1. Hydrogen fuel cells
   - Improved fuel cell cathode catalysts for oxygen reduction

2. Ethanol fuel cell range extenders
   - Highly efficient multi metallic anode materials for Direct Ethanol Fuel Cell Range Extenders

3. High capacity magnesium batteries
   - Intercalation and reversibility of Mg ions in oxide electrodes

4. PEM and alkaline water electrolyzers
   - Low cost catalysts for acid and alkaline water splitting
Electrical Energy Storage Systems
E-Mobility Research Interests and Competencies

1. Simulation models of energy storage systems
   - Electrical and thermal models for system simulation and design
   - Model based lifetime prediction

2. Performance tests of cells and storage systems
   - Power tests of different battery and energy storage technologies
   - Lifetime tests under different conditions
   - Parameterisation measurements for simulation models

3. Post mortem analysis
   - Opening of cells before and after lifetime tests
   - Investigation of ageing mechanisms

4. Comparison of storage systems for electric vehicles
   - Technical and economic comparison of different storage technologies

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Research Area
Vehicle and Manufacturing Concepts
1. New concepts for Electric Transport Solutions (ETS)
   - Electrified transport systems in urban areas
   - Concepts for ultra-light vehicles, buses and utility vehicles

2. Electric vehicle system simulation
   - Drive cycle simulation for buses and utility vehicles
   - Energy consumption simulation for commercial vehicle fleets
   - Simulation and measurement of Heating and Air Conditioning

3. Total cost of ownership assessments
   - Economic and technical assessment of electric urban transport systems
   - TCO-forecasting of complex systems based on stochastic simulation

4. Technology Roadmapping (TRM) for e-mobility
   - Success factors of technology roadmapping – an industry survey
   - Development of guidelines for effective TRM

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1. Process chain development for the manufacturing of core components for e-mobility
   - Resource efficient process chains for the manufacturing of batteries, power electronics and electric motors

2. Advanced manufacturing and joining technologies for a hybrid lightweight design for e-mobility platforms
   - Innovative cutting and finishing technologies for multi-material components
   - Tools and methods for maintenance, repair and overhaul of e-mobility systems
   - Impulse magnetic joining and welding for vehicle-lightweight vehicles

3. Development of modular E-MicroCarrier
   - Modulare MicroCarrier with E-drive for multifunctional urban supply of goods
Automotive Engineering
E-Mobility Research Interests and Competencies

1. Car concepts with combustion and alternative drive systems
   - Comparison of different EV architectures and energy storage systems
   - Optimization of total CO₂ impact (well-to-wheel)

2. Electric drive train simulation and optimization
   - Simulation for different EV drive trains
   - Optimization of battery size, engine power and power train control

3. Heating and air-conditioning systems for EVs
   - Reduce energy and power demands of the HVAC system
   - Comparison of different heating and cooling technologies

4. EV usage
   - Logging real EV usage with small data loggers
   - Development of guidelines for users, marketing and engineers
Quality Science
E-Mobility Research Interests and Competencies

1. Reliability of the product life cycle
   - development and application of preventative methods for the analyzing and covering of the product- and process quality of e-mobility systems
   - development of methods and criteria for the quality evaluation of e-mobility systems in the product life cycle

2. Quality management for e-mobility concepts
   - quality planning, quality management and quality controlling in the value net of e-mobility; quality management for and certification of e-mobility business concepts and operator models
Industrial Information Technology
E-Mobility Research Interests and Competencies

1. Methods for the functional design of hybrid vehicle concepts:
   - Functional mock-up solutions for the validation of mechatronic (sub-) systems
   - Multi material structures (lightweight construction), production system simulation

2. Interactive testing and validation of innovative vehicle concepts using virtualized environments:
   - Experienceable evaluation of new vehicular interaction concepts
   - Testing and validation of future e-mobility solutions and infrastructure concepts

3. PLM solutions for e-mobility
   - Holistic data and process management for the integrated interdisciplinary development of vehicles and infrastructures
   - Feedback of use and maintenance knowledge into the development cycle

4. Innovative approaches for planning and digital support for the maintenance, repair and overhaul of e-mobility solutions
Assembly Technology and Factory Management
E-Mobility Research Interests and Competencies

1. Value Creation Analysis of the Manufacturing Process of Lithium-Ion Batteries
   - Assessment of manufacturing costs considering the individual process value contribution
   - Development of a stochastic simulation algorithm to forecast necessary investments in production resources to economically manufacture lithium-ion batteries

2. Innovative Assembly Technologies
   - Developing innovative and high-throughput solutions for handling battery cells
   - Assessing the potentials of shifting from discrete pick-and-place operations to a continuous process flow in assembling battery cells

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Research Area
Transportation Systems and Mobility Concepts
Transportation Planning
E-Mobility Research Interests and Competencies

1. Research on Actors
Central to our research is the analysis of the motivations of transport users, with a special emphasis on recurring patterns of action and how these mobility routines can be influenced before they harden into mobility patterns.

2. Researching the Future
The scientific study of future-related issues encompasses the systemic analysis of possible, probable and desirable futures. From the specific standpoint of designing the future of transport and mobility, structural analyses are linked with the perspectives of the various actors involved.

3. International Research
We investigate the different pathways of global developments in transport systems as well as the various concepts of transport planning. We are especially interested in the specific cultural, social and political parameters and their importance for the development of transport and mobility.
1. Smart and sustainable cities – co-modal e-mobility
   - Long research history in co-modal urban e-mobility, e.g. adaptive environmental zones, green routing, eco-driving assistant systems
   - Test vehicles allow fast prototyping and testing of novel e-mobility apps
   - Cooperation with Daimler AG in DCAITI An-Institute (www.dcaiti.tu-berlin.de)

2. Large-scale simulation of e-mobility apps - VSimRTI
   - Large-scale simulation of communication enabled vehicles including vehicle-2-x (ITS G5, Smart Grid) and infrastructure-based (UMTS/LTE) communication
   - Assessment of e-mobility application benefits including environmental effects
Logistics
E-Mobility Research Interests and Competencies

1. Green logistics
   - Resource efficient transport systems in city logistics
   - Sustainability measurement methods
   - Integration of electrified transport in urban distribution concepts

2. Logistics strategy and best practice
   - Analysis of trends and strategies in logistics systems
   - Development of sustainable logistics strategies with customer focus

3. Transport logistics and management
   - Management of freight transport networks
   - Development of business models and concepts of collaboration for the utilization of electric transport in city logistics
1. TU Campus EUREF
   - Development of new teaching formats: Master's degree programs, further education and support for young entrepreneurs

2. EUREF research campus: Mobilitiy2Grid
   - Determination of transport engineering requirements for an E-fleet operation: Mobility concepts, charging infrastructure, acceptance research
   - Energy consumption simulation using real drive cycles for commercial vehicle fleets
1. Energy efficient urban transportation systems
   - Individual traffic – two and four wheelers
   - Public transport and commercial traffic

2. Urban infrastructure for electric mobility
   - Charging facility concepts for passenger vehicles, busses and commercial traffic
   - Traffic management
   - Requirement of different user groups – drivers, operators, municipality

3. Evaluation of the application of emission-free urban transport
   - Integrated analysis and evaluation of the feasibility, transferability and impacts of electric propulsion in urban transport
   - Cost-benefit-analysis and multi-criteria effect analysis
Sustainable Engineering

E-Mobility Research Interests and Competencies

1. Environmental assessment of e-mobility concepts
   - Carbon footprint
   - Water footprint
   - Life cycle assessment

2. Resource availability and efficiency of e-mobility concepts
   - Geological and physical availability of resources
   - Socioeconomic availability and supply risk of raw materials
   - Resource efficiency analysis

3. Sustainability assessment of e-mobility concepts
   - Life cycle costing
   - Social life cycle assessment
   - Life cycle sustainability assessment

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Work and Technology
E-Mobility Research Interests and Competencies

1. Participative development of electric two wheelers and ultra light vehicles
   - Participative development of utilization concepts for different target groups, maintenance, life cycle management optimization of vehicles in collaboration with producers, assessment and evaluation of operation conditions.

2. Participative development of new transport concepts for urban electromobility
   - Micromobile transport concepts an transport chains
   - Fast bycicle lanes, interactive controlled loading

3. Electromobility as a subject for technical teaching and communication
   - Electromobility as a subject for technical teaching and communication
   - Electromobility in schools, project orientated learning in schools, student companies, communication of electromobility.
Sociology of Planning and Architecture
E-Mobility Research Interests and Competencies

1. The field of Sociology of Planning and Architecture specializes in analyzing the structures and interplay of designed space, patterns of mobility, and social actions

2. The overall objective is to enhance our understanding of cities, urban neighborhoods, regions and other forms of urban agglomerations in the context of planning policies and decisions, new forms of mobility, and social processes of appropriation.
Research Unit „Mobility and Space“

E-Mobility Research Interests and Competencies

Core competencies of the CTS (ZTG), Research Unit „Mobility and Space“ are the integration of the E-Mobility in urban and transportation planning, combination of lifestyle research with the use of lasting “mobility tools”, like electric vehicles, and the employment concepts of electrically operated vehicles.

1. Integration of Electric Vehicle System in Urban Planning
   - Electric vehicle system as part of integrated transport and urban planning
   - Strategies and measures to promoting electrical powered vehicles
   - Legal aspects to promoting electrical cars and two-wheelers
   - Land-use aspects of E-Mobility

2. Sustainability and Electric Transportation Systems
   - Energy and emission balance of electrified transport systems
   - E-Mobility as strategy for reducing GHG- emission and energy consumption

3. User behavior and electrical road vehicles
   - Evaluation of use problems of electrical powered vehicles
   - User Acceptance research of electrical vehicles

4. Electrical vehicle in commercial fleets
   - Use of electrical vehicles in Urban Commercial Transport

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Research Area
Charging Infrastructure and Grid Integration
Agent Technology, DAI Laboratory
E-Mobility Research Interests and Competencies

1. Smart integration of electrical car fleets into (distributed) micro smart grids
   - Implementation of systems for planning and regulating of the energy distribution in Micro Smart Grids, with the integration of electric fleets, such as car sharing fleets, commercial fleets, and fleets of larger utility vehicles.
   - Simulation of Micro Smart Grids to assess and demonstrate the economic and ecological feasibility base on a variety of scenarios.

2. Integration of e-mobility into intermodal traffic and travel concepts in Smart Cities and adaptive and integrated services around E-Mobility
   - Providing of platforms to integrate electric vehicles in holistic intermodal city traffic and travel concepts by utilizing technologies for semantic descriptions of services for better integration and interconnection.
   - Focus on usability and easy, flexible and integrated access for users to heterogeneous mobility services and services around E-Mobility.
Energy Systems
E-Mobility Research Interests and Competencies

1. Evaluation of GHG emission strategies for e-mobility
   - Direct and indirect greenhouse gas (GHG) emissions
   - Renewable electricity supply and vehicle charging

2. Optimal electricity purchase strategies for e-mobility
   - Institutional settings of European electricity markets
   - Roles of aggregators and balancing group managers
   - Integrated Systems analysis of vehicle utilization profiles, charging infrastructures and electricity markets

3. Power-to-Gas
   - Renewable electricity supply chains for road mobility
   - Comparative cost assessment of new fuels
   - Regulatory impacts on markets

4. Intelligent infrastructures and safety
   - Risk analysis assessment
   - Risk mitigation strategies

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1. Planning, organization, financing of infrastructure facilities
   - Need for technical and institutional standardization
   - Economic analysis of organizational and management models
   - Financing models and pricing options

2. Regulation of public and private utilities
   - Public procurement and public private partnership in infrastructure sectors
   - Competition strategies of private firms and competition policy in network industries
   - Environmental and social impacts of infrastructure provision
   - Operating models and incentive systems within federal systems applied to:
     - Charging infrastructure (public, semi-public, private)
     - Mobility platforms and multimodal mobility concepts

3. Analysis of coordination between different actors

4. Interdisciplinary research, cooperation with lawyers and engineers
Sustainable Electric Networks & Sources of Energy
E-Mobility Research Interests and Competencies

1. komDrive: Electrification potential of commercial fleets
   - Potential of commercial EV fleets as a resource in the grid
   - Storage of locally generated electricity

2. NET-INES: Network integration of mobile energy storage
   - Ancillary grid services offered by EVs
   - Technical and economic potential of such services

3. SuSTAINABLE: Smart distribution system operation
   - Virtual power plant design with integrated EVs
   - Optimized operation of power grids with renewable energy and EVs
   - Power quality impact of EVs

4. Smart grid laboratory
   - Test-based evaluation of physical EV charging
   - Imbalance in three-phase systems due to single-phase charging
   - Demand side management with EVs and smart households
Research Area
Integration Technologies and Drive Train Concepts
1. Power semiconductor devices and converters
   - Converter topologies applying emerging power semiconductor devices based on SiC and GaN for efficient drive trains and auxiliaries
   - Converter design combining packaging, thermal and electrical design in compliance with the demanding environmental constraints of automotive applications

2. Reliability
   - Long term-tests of power semiconductor devices investigating thermomechanical stress and lifetime monitoring

3. Control of power electronic converters
   - Control of DC/DC and DC/AC converters
   - Real-time simulation and PHIL
Electrical Drives
E-Mobility Research Interests and Competencies

1. Energy efficient electric drives
   Improvement of low load efficiency by
   - motor design (e.g. $L_d > L_q$)
   - software based multi-dimensional geometry parameter search
   - online minimum loss search

2. EV control
   - Innovative controllers for EVs by using
   - FPGA based direct torque control
   - Modular battery management

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1. Modeling and diagnosis of mechatronic systems
   - Modeling of mechatronic systems (electric machines, EVs, automotive transmissions) as well as energy storages (batteries).
   - The models are integrated both in diagnostic systems and in control algorithms.

2. Identification/parametrization of nonlinear systems
   - Identification methods for highly nonlinear system models (batteries)
   - Design-of-Experiments for measurement time reduction and information retrieval

3. Infrastructure
   - Power train test bench
   - Battery-simulator (80 kW)
   - Different battery test benches
   - Research EV
1. Energy efficient drive trains
   - Complete drive train optimization including hybrid components
   - Identification of unused potential concerning emissions and fuel consumption under real driving situations applying unconventional engine design opportunities
   - Identification of degree of freedom concerning of new fuels and combustion strategies through electrification
   - Tool development and model adjustment

2. Downsizing options through electric turbocharging
   - Evaluation of electric boosting options
   - Test and simulation of impact to transient behavior and fuel consumption