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KONRAD ADENAUER STIFTUNG

Mobility Transformation

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Publisher	Konrad- Adenauer-Stiftung e. V.
Editor	Konrad- Adenauer-Stiftung e. V. Korea Transport Institute
Publication Date	May 27, 2024
Address	2F. 13, Changdeokgung 1-gil, Jongno-gu, Seoul, Republic of Korea (03058)
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ISBN 979-11-987682-0-9 (95330)

Table of **Contents**

AUTHORS

Foreword

Thomas Yoshimura

Resident Representative in Korea, Konrad-Adenauer-Stiftung e.V.

Thomas Yoshimura studied at the University Duisburg-Essen and the Ryukoku University in Kyoto and holds a Diploma in Regional Studies East Asia. He joined the Konrad-Adenauer-Stiftung in 2011 and served as Project Manager in the then established Representative Office in Tokyo. In 2014 he was transferred to Jakarta as Assistant Representative and Acting Director of the KAS Office for Indonesia and Timor-Leste. Thomas returned to KAS headquarters in 2016 and spent two and a half years in charge of ECM Training Management. In 2019 he became responsible for the Desk for Japan, Korea, Australia, New Zealand and the Pacific, before in May 2020 he was designated as next Resident Representative in Korea and took office on 1 August 2020. The projects of KAS in Korea have since been shifting their focus to perceptions and developments of the global and regional order in terms of security as well as to autonomous driving and all matters related to a sustainable mobility transformation across the Indo-Pacific under the pillar of innovation.

The Direction and National Strategies for the Great Mobility Transformation

Dr. JaeHak Oh

President, Korea Transport Institute

Dr. Jaehak Oh is the president of Korea Transport Institute(KOTI) since 2017. KOTI is the national transport research institute under the Office of Prime Minister. Dr. Oh was the president of EASTS (East-Asian Society of Transportation Studies) for 2019 to 2023 and currently serving as a Steering Committee member of WCTR-Society. Dr. Oh graduated Department of Industrial Engineering at Seoul National University in 1980 and obtained his Ph.D. degree in Transport Studies at University College London in 1990. During the last 32 years at KOTI, Dr. Oh has managed more than 70 of KOTI's transport and logistics research projects. He has played a key role in innovating transport systems for carbon neutral, implementing public transport-oriented policies and formulating national transport infrastructure investment plans for the Korean government. During 2006 to 2011, He was the project manager of the national R&D, "Transport Connectivity and Transfer Technology Development" and "High-Speed Railway Station Development". In recent years, Dr. Oh plays a leading role in conducting national researches on mobility transformation of automation, electrification, car-sharing and integration.

Transforming Mobilty in Germany through the Regional Innovation "Mcube"

Oliver May-Beckmann

Managing Director, MCube - Munich Cluster for the Future of Mobility at Technical University of Munich

Oliver May-Beckmann studied at the University of Otto Friedrich Bamberg in Germany, holds a Diploma in Political Science and Business Administration. He has over four years of experience at the Konrad-Adenauer-Stiftung's international department(2008-2012), serving as Project Coordinator in Hanoi, Vietnam and later as Head of Division for Northeast Asia in Berlin, Germany. From 2012 - 2016, Oliver established in a small team the Social Entrepreneurship Akademie in Munich as a joint initiative of four major universities and their entrepreneurship center. In Shanghai, China from 2016 - 2018, Oliver worked as a Partner at the German-Chinese innovation agency Constellations on a bilateral accelerator program for "citymakers" in collaboration with the Robert Bosch Stiftung. From 2018 - 2020 he continued this work in Boston, USA. From 2020 to 2022, Oliver was the Head of Entrepreneurship Education and Ecosystem Development at the Stascheg Center for Entrepreneurship at the University for Applied Science in Munich, focusing on fostering innovation programs with industry partners and startups.Since 2022, Oliver has been the Managing Director of MCube at TUM, a >50 Million EUR flagship initiative exploring sustainable mobility innovation supported by the German government. MCube aims to position Munich as a global leader in sustainable mobility, committed to efficiency and social equity.

Dr. Alexander Wentland

Senior Researcher, Munich Cluster for the Future of Mobility in Metropolitan Regions(MCube) / Head, Researcher Group Transforming Mobility and Society at Technical University of Munich

Dr. Alexander Wentland has been awarded a Magister degree in Political Science from Technische Universität Dresden and holds a Master's degree in Sociology from the New School for Social Research. He successfully completed his doctoral thesis at Technische Universität Berlin and Harvard University in 2018. In his professional capacity, Dr. Wentland is responsible for leading the strategic domain "Mobility & Society" within the Munich Cluster for the Future of Mobility in Metropolitan Regions (MCube), where he also serves as the principal investigator for three distinct projects. His research endeavors are situated at the confluence of Science & Technology Studies (STS), Sociology, and Mobility Studies, with a particular focus on understanding the implications of technological trends on the fabric of democratic politics, encompassing both national discourses and local experimental zones.

Dr. Julia Kinigadner

Senior Researcher, MCube - Munich Cluster for the Future of Mobility in Metropolitan Regions / Head of Research Group on Integrated Mobility Concepts at the Technical University of Munich

Dr. Julia Kinigadner graduated from the international study program in Environmental Engineering at the Technical University of Munich and received her PhD in engineering at the Technical University of Munich. From 2014 to 2020, she served as Research Associate at the Chair of Urban Structure and Transport Planning. Since 2020, she is Head of a Research Group on Integrated Mobility Concepts at the Chair as well as a member of the strategy team of the MCube Cluster. Her research focuses on Sustainable Mobility strategies at different spatial scales and is closely linked to planning practice and policy in the Munich region.

Sophia Knopf, M. A.

Project Coordinator at the Munich Cluster for the Future of Mobility(MCube) / Doctoral Researcher at the Technical University of Munich(TUM)

Sophia Knopf holds a degree in Communication Science and Psychology from the Ludwig-Maximilians-University Munich and in Responsibility in Science, Engineering and Technology from the Technical University of Munich. In 2018 she was a junior researcher at the IT University of Copenhagen and from 2017 to 2020 she worked at the Institute for Social Science Research e.V. in Munich. In 2022, she was a visting fellow in the Program on Science, Technology and Society at the Harvard Kennedy School of Governance. Since 2020, Sophia Knopf has been a project coordinator and researcher at MCube and a doctoral student at the TUM School of Social Sciences and Technology. Her research focuses on the societal implications of innovation, in particular the topics of responsible innovation, data-driven cities and digital urban twins.

Technological Aspects of Mobility Transformation in Germany

Friedemann Kallmeyer

Mobility Researcher

Friedemann Kallmeyer studied transport engineering with a specialization in transport planning and technology at the Technical University of Dresden, Germany and is a graduate engineer with special reference to cross-modal transport issues and vehicle automation. His work focuses on public transport and environmentally friendly means of transport, autonomous driving, new and sustainable mobility services and concepts, logistics, rail transport and rail infrastructure. From 2021 to 2023, he worked as Senior Research Associate and Head of Mobility at the Institute for Climate Protection, Energy and Mobility(IKEM). His work at IKEM focused on the economic evaluation, conception and analysis of mobility concepts and business models for all modes of transport and the examination of their transferability. Since the end of 2023, Friedemann Kallmeyer has been working as a project manager for digitalization projects in public transport and rail transport in Germany.

Katharina Csillak

Geographer and Mobility Researcher

Katharina Csillak studied geography with a minor in Asian and African regional studies at Humboldt University in Berlin where she also completed her master's degree in Urban Geographies. During her studies, she specialized in the field of urban and transport planning with a special focus on sustainable and climate-compatible design of public space. Her master thesis is about the possibilities to implement car-free neighborhoods. From 2017 to 2020, she worked as a research assistant at the German Institute of Urban Affairs GmbH(Difu) in the research area of mobility. She worked in various projects on topics related to walking and cycling, as well as climate-friendly and innovative mobility concepts - including Mobility as a Service, mobility stations, inter-/multimodality. From 2021 to 2023, she worked as a senior researcher at Institute for climate protection, energy and mobility(IKEM) in the mobility department. During her work, she was a project leader for a European project about electromobility and charging infrastructure. Beside this, she focused on topics around gender equality in transport, bicycle infrastructure and sustainable urban mobility. Currently, Katharina Csillak is working as a Senior Consultant at TÜV Rheinland Consulting GmbH in the field of research management. Her focus is still on a sustainable mobility in urban and rural areas.

Technological Aspects of Mobility Transformation in Korea

Dr. Kyeong-Pyo Kang

Director / Senior Research Fellow, Center for Connected and Automated Driving Research, Korea Transport Institute

Dr. Kyeong-Pyo Kang received the Ph.D. degree in transportation engineering at the University of Maryland at College Park(UMCP), U.S.A. in 2006. His research is focused mainly on the advanced highway operations based on the intelligent transportation systems(ITS). He is currently working in the Korea Transport Institute(KOTI) as a senior research fellow since graduated UMCP. He conducted connected and automated mobility related research and development(R&D). Specially, the CAPTAIN(Connected and Automated Public TrAnsport system INnovation) and SHARING(Shared High Automated Routing INnovation Group) are key projects to promote the automated vehicle deployment in Korea, with the Cooperative ITS(C-ITS) based roadway digital infrastructures. He is also involved in C-ITS pilot deployment project, by supporting the ITS division in Ministry of Land, Infrastructure and Transport(MOLIT) and international cooperation with U.S. DOT(department of transportation), and EC DG(Directorates-General) CNECT(Communication Network and Technology) in the field of ITS.

Dr. Taehyung Kim

Director / Senior Research Fellow, Center for Smart City and Transport, Korea Transport Institute

Dr. Taehyung Kim earned his Ph.D. degree in the Department of Civil and Environmental Engineering at the University of Maryland, College Park in 2005. Since his joining the KOTI in 2005, he has been involved in various research projects related to ITS policy, planning and smart mobility in smart city. He also carried out various ITS-related R&D projects such as ubiquitous transportation systems and automated vehicle highway systems(AVHS). Recently, he has been working on various Smart City R&D projects focusing on developing core technologies and pilot test of Smart Mobility including mobility-as-a-service(MaaS), demand responsive transit(DRT) and automated vehicle service. He also has been working as a Master Planner(MP) for Mobility areas in National Smart City Pilot Project in Korea. He currently works as a Director of Center for Smart City & Transport at Korea Transport Institute(KOTI). He worked as a Senior Transport Specialist in Transport & ICT Global Practice at the World Bank from the year 2015 to 2017.

Dr. Jiyoung Park

Director / Research Fellow, Division for Mobility Strategy & International Cooperation, Korea Transport Institute

Dr. Jiyoung Park is a Research Fellow at Korea Transport Institute. Her work is centered on exploring the impact of new technology such as Electric Vehicles and Autonomous Vehicles on transportation system. Dr. Park's recent works include a national plan for electrification of freight vehicle in Korea supported by Ministry of Environment of the Republic of Korea and a preliminary study on the impact assessment of autonomous vehicle on transportation system supported by National Research Council of Korea. Also she has conducted EV user surveys since 2014 and analyzed the characteristics of EV customers in Korea. She received a B.S. in Civil Engineering from Seoul National University in 1997 and a Ph.D. from University of California at Irvine in 2009.

Dr. Sunghoon Kim

Associate Research Fellow, Center for Smart City and Transport, Korea Transport Institute

Dr. Sunghoon Kim was born in Seoul, South Korea, in 1984. He received a B.A. degree in physics(minor in mathematics) from the University of Southern Maine, Portland, USA, in 2008, and M.S. and Ph.D. degrees in civil and environmental engineering from KAIST, Daejeon, South Korea, in 2013 and 2018, respectively. After receiving his degrees, he joined the Applied Science Research Institute at KAIST in 2018 and served as a postdoctoral researcher. Then, he joined the Department of Civil and Environmental Engineering at KAIST in 2019 and served as a Research Professor. In 2021, he joined the Korea Transport Institute(KOTI), and he is currently serving as an Associate Research Fellow at the Center for Smart City and Transport. His research interests include smart mobility in smart cities, mobility as a service(MaaS), future urban mobility(demand responsive transit, urban air mobility, and micro-mobility), intelligent transportation systems(ITS), autonomous vehicle operations, advanced traffic control, vehicle traffic simulation, and pedestrian simulation.

Legal and Institutional Improvements in Germany

Ass. iur. Giverny Cathrine Knezevic

Senior Research Associate, Institute for Climate Protection, Energy and Mobility

Giverny Knezevic studied law at the Viadrina in Frankfurt(Oder) and the Université Montpellier with a focus on European law. After her studies, she did an internship at a law firm for EU competition law in Brussels and subsequently worked in the Scientific Service of the European Court of Justice as an administrator. She finished her legal clerkship in Aachen and completed e.g. internships at the Federal Ministry for the Environment in Berlin. She joined the Mobility Team at IKEM in May 2021 as a Senior Research Associate and focuses on the electrification of the transport sector and sector coupling. Based in Brussels, she is IKEM's representative at the EU.

Timon Plass

Senior Research Associate, Institute for Climate Protection, Energy and Mobility

Timon Plass studied law at the Alberts-Ludwigs-University Freiburg and the National and Kapodistrian University Athens with a focus on intellectual property law. He conducted his legal traineeship at Landgericht Chemnitz which included a stage at the Legal Directorate of the MDR Leipzig and at a law office specialized in family law. Timon Plass is a Senior Research Associate and expert on autonomous driving at the Institute for Climate Protection, Energy and Mobility. He is involved in various projects(ahoi, NoWel4, ABSOLUT II) on legal issues related to autonomous driving as well as the automation of public transportation. In the AStriD project, he examined the legal issues surrounding the operation of an autonomous streetcar. His research also covers public transportation, new and sustainable mobility services, as well as national and international data protection regulations.

Legal and Institutional Improvements in South Korea

Prof. Keeyeon Hwang

Invited Professor, Department of Electrical Engineering, Korea Advanced Institute of Science & Technology (Former President of KOTI)

Prof. Keeyeon Hwang earned his doctoral degree from the University of Southern California in 1992. Currently, he holds the esteemed position of invited professor at the Department of Electrical and Electronics Engineering at the Korea Advanced Institute of Science & Technology(KAIST). Before joining KAIST, Dr. Hwang made significant contributions to transportation engineering at Hongik University, where he served as a professor, dean of the engineering school, and vice president. Moreover, he distinguished himself as the 11th president of the Korea Transport Institute. Since 2016, Dr. Hwang has chaired the Intergovernmental Forum on Automated Vehicle, showcasing his expertise in cutting-edge transportation technologies. His extensive contributions have profoundly influenced the advancement of urban mobility policy and planning, establishing him as a pivotal figure in the field.

Dr. Kyuok Kim

Director / Senior Research Fellow, Center for Future Vehicles, Korea Transport Institute

Dr. Kyuok Kim has specialized expertise in future vehicle research as a senior research fellow and he is in charge of head for the future vehicle at the Korea Transport Institute. His focus areas include policy and technology related to automated vehicles, electric vehicles, and smart mobility, contributing significantly to the transformation of mobility. He has been involved in various projects such as the development of government vehicle policies, the creation of a master plan for automated vehicles, and the formulation of the ASEAN smart mobility strategy. With a Ph.D. in Transportation Engineering from Texas A&M University, he has also worked as a postdoctoral fellow and visiting scholar at the Texas A&M Transportation Institute. Furthermore, he plays an active role as an international standard expert in ISO TC 204 for Intelligent Transport Systems(ITS).

Towards New Mobilty Paradigms

Prof. Myounggu Kang

Professor, Department of Urban Planning and Design, University of Seoul

Dr. Myounggu Kang holds a Master in City Planning(MCP) and a PhD from MIT, and a Bachelor and a Master degree from Seoul National University. He has been appointed Professor of Urban Planning and Design at the University of Seoul since 2006, where, next to his appointment, he is the Director of Urban Big Data and Artificial Intelligence Institute(UBAI), Director of Smart City Research Center(SCRC) and the editor of the International Journal of Urban Sciences(IJUS). He also serves as a senior urban specialist at the World Bank. Former appointments include the position of the Vice President of International Affairs at the University of Seoul, and the Director-General of International Urban Development Collaboration at Seoul Metropolitan Government(SMG), among others.

Dr. Youngho Kim

Chief Director / Senior Research Fellow, Department of Mobility Transformation, Korea Transport Institute

Dr. Youngho Kim is the Chief Director in the Mobility Transformation Research Department at Korea Transport Institute. He began his career at KOTI in 2005 and has held managerial positions in various research departments, including metropolitan transport, traffic safety, national transport strategy, and mobility innovation. He has led approximately 70 national transport policy and transport operation projects and has authored 30 research papers published in international and domestic journals. From 2017 to 2018, he served as a Senior Transport Specialist and contributed to five lending projects and knowledge sharing activities at the World Bank. Before joining KOTI, he worked as a Research Associate at McMaster University in Canada and taught at Youngsan University. Dr. Kim obtained his undergraduate and graduate degrees from Seoul National University and earned his Ph.D. in Transport Engineering from Munich University of Technology in 2002.

Public-Private Cooperation for Mobility Transformation

Dr. Sunghoon Kim

Associate Research Fellow, Center for Smart City and Transport, Korea Transport Institute

Dr. Sunghoon Kim was born in Seoul, South Korea, in 1984. He received a B.A. degree in physics(minor in mathematics) from the University of Southern Maine, Portland, USA, in 2008, and M.S. and Ph.D. degrees in civil and environmental engineering from KAIST, Daejeon, South Korea, in 2013 and 2018, respectively. After receiving his degrees, he joined the Applied Science Research Institute at KAIST in 2018 and served as a postdoctoral researcher. Then, he joined the Department of Civil and Environmental Engineering at KAIST in 2019 and served as a Research Professor. In 2021, he joined the Korea Transport Institute(KOTI), and he is currently serving as an Associate Research Fellow at the Center for Smart City and Transport. His research interests include smart mobility in smart cities, mobility as a service(MaaS), future urban mobility(demand responsive transit, urban air mobility, and micro-mobility), intelligent transportation systems(ITS), autonomous vehicle operations, advanced traffic control, vehicle traffic simulation, and pedestrian simulation.

Younghun Lee

Principal, Smart City Business Unit, LG CNS

Younghun Lee completed his doctoral program in the Department of New Industry Convergence at Konkuk University and graduated with a master's degree in business administration from the KDI School of Public Policy and Management. In 2019, he received the Minister of Land, Infrastructure and Transport Award for his work related to MaaS, and in 2020, he received the UX Grand Prize from the Design Association. He started his career in the ITS field, including road traffic and railway signals, when he joined LG Industrial System's overseas business team in 1997. In 2010, he served as the head of the Hyundai Card Alliance Marketing team, launching million-seller card products with Hi-mart, CJ, and others, exceeding 1 million units. In 2017, he served as the representative of the Deal Car CIC, established by Hyundai Capital for the promotion of MaaS and CaaS businesses, and proposed the direction of mobility for the Hyundai Motor Group. Currently, he is working as a Principal in the LG CNS Smart City Business Unit, overseeing the MaaS and mobility services of the Sejong Smart City and Busan Smart City projects.

Hyocheol Park

Specialist, Public Service & Smart City Strategy Business Team, LG CNS

Hyocheol Park, alumnus of Hankuk University of Foreign Studies, holds a Bachelor's in Arts and Business. He explored several industrial fields before settling into the mobility industry. In 2019, he joined 'SOCAR' a leading mobility company in Korea, and dedicated three years to improving margins and innovating internal processes. In 2022, he transferred to LG CNS, driven by his pursuit to integrate smart services into ordinary daily life.

Socioeconomic Impacts of Mobility Transformation

Dr. Kyungyou Kim

Director / Senior Research Fellow, System Industry Division, Korea Institute for Industrial Economics & Trade

Dr. Kyungyou Kim completed a PhD programme in business administration at Hankuk University of Foreign Studies. He is currently working at the Korea Institute for Industrial Economics & Trade, where he is in charge of the automotive industry. He is researching development strategies and promotion policies for the automotive industry, which plays an important role in domestic industrial development and economic growth.

About Publication

Technology is moving fast and affecting all dimensions of our environment including our perceptions and expectations of how to use and connect space. Both as a product and enabler of these developments, new forms and patterns of movement and transport become possible and desirable. As design and first steps of implementation in the process of Mobility Transformation across our countries enter a decisive phase, they become more apparent and tangible for ordinary people and therefore a focus of public debate on defining priorities of our economies and societies alike. We need to address both how to shape the future of mobility as well as how to mitigate risks and concerns accompanying these developments.

This joint publication together with the Korea Transport Institute(KOTI) provides an exemplary overview of visions and approaches in Germany and Korea for their respective Mobility Transformation. Both are leading nations when it comes to technological progress as well as necessary legal frameworks in this field, but show complimentary instruments and ideas. Their comparison is meant to illustrate the nexus of pathways leading to a comprehensive and sustainable Mobility Transformation by analyzing specific scenarios or cases, utilizing practical experience and extrapolating methodological models for policy makers in both countries and beyond crafting sustainable mobility transformation strategies in their own context.

Editors

KONRAD-ADENAUER-STIFTUNG

Konrad-Adenauer-Stiftung(KAS) is a political foundation active throughout Germany and abroad. Nationally and internationally, KAS is committed to achieving and maintaining peace, freedom and justice through political education. We promote and preserve freed democracy, the social market economy, and the development and consolidation of value consensus.

KOREA TRANSPORT INSTITUTE

Korea Transport Institute(KOTI) is a comprehensive research agency in the nation and actively works to develop national transport policies and transport technologies. KOTI works to improve people's lives and contribute to economic development by conducting comprehensive research and development on transport and logistics policies and technologies by collecting, analyzing, and sharing various transport data.

Foreword

Thomas Yoshimura
Resident Representative in Korea | Konrad-Adenauer-Stiftung e.V.

In the dynamic landscape of the 21st century, the paradigm of mobility is undergoing profound transformation, reshaping the way we move, connect, and interact with our surroundings. Both Germany and South Korea are scaling up their efforts to find a spot at the forefront of technological innovation, and their visionary policies are reshaping their mobility ecosystems.

The significance of mobility transcends convenience, as it is a cornerstone of societal progress, economic vitality, and environmental sustainability. As we stand on the cusp of a new era in which traditional modes of transportation are being reimagined and revolutionary technologies are poised to redefine our understanding of mobility, the need for a comprehensive exploration of these transformations is becoming increasingly urgent.

This publication delves into the intricacies of mobility transformation in Germany and South Korea, providing a nuanced understanding of current developments, government policies, and the state of discussions surrounding technology, legal frameworks, and socioeconomic impacts. Both nations have emerged as pioneers in the quest for sustainable and intelligent mobility solutions, contributing unique perspectives shaped by their historical, cultural, and economic contexts.

Germany's world famous automotive industry is undergoing radical metamorphosis spurred by climate change, urbanization, and the pursuit of cutting-edge innovation. The country's commitment to fostering electric mobility, advancements in autonomous driving, and integration of digital platforms are emblematic of its vision of a smarter, greener transportation future.

On the other side of the globe, South Korea, renowned for its rapid technological advancements, is navigating a dynamic landscape where smart infrastructure, 5G connectivity, and electric mobility are converging to redefine the very fabric of transportation. Bold initiatives by government and industry leaders, combined with a forward-thinking approach to regulation, have positioned South Korea as a global leader in shaping the future of mobility.

The ongoing discourse surrounding mobility transcends technological advancements and encompasses the legal and regulatory frameworks that must evolve to accommodate these innovations. From liability concerns in autonomous driving to the ethical considerations of data usage, the legal landscape is as integral to the mobility revolution as technological advancements.

As we explore the socioeconomic impacts of mobility transformation, we encounter a complex interplay of factors, including employment patterns, urban planning, and the democratization of access to transportation. The choices made today will shape tomorrow's cities and societies, influencing the quality of life, environmental sustainability, and economic resilience of future generations.

This publication serves as a compass, guiding readers through the multifaceted terrain of mobility transformation in Germany and South Korea. It is a testament to the collaborative efforts of policymakers, industry leaders, and innovators, who are steering these nations towards a future in which mobility is not just a means of transportation but a catalyst for progress, sustainability, and inclusivity.

Why Germany and South Korea

Germany and South Korea have positioned themselves at the vanguard of technological innovation and visionary policies that are reshaping their mobility ecosystems through a combination of historical contexts, strong industrial bases, and forward-thinking government initiatives. Four reasons highlight why these two countries are natural mobility innovation leaders and possible role models by themselves, as well as partners for each other and other countries.

Germany:

1. Automotive Prowess: Germany has long been known for automotive excellence and is home to renowned companies such as Volkswagen, BMW, and MercedesBenz. The country's automotive industry has a rich heritage and deep commitment to innovation, making it a global leader in vehicle manufacturing.
2. Commitment to Sustainability: Faced with environmental challenges, Germany has taken a bold stance on sustainability. Subsequent governments have implemented ambitious policies to transition towards electric mobility, encouraging the production and adoption of electric vehicles(EVs). This commitment aligns with global efforts to reduce carbon emissions and combat climate change.
3. Research and Development: Germany boasts a robust R&D ecosystem that fosters collaboration between industry and academia. Investments in cutting-edge technologies, such as autonomous driving, connected vehicles, and smart infrastructure, have helped position the nation at the

forefront of mobility innovation.

4. Digitalization and Industry 4.0: Germany championed the concept of Industry 4.0, which emphasizes the integration of digital technologies into manufacturing processes. In the context of mobility, this translates to advancements such as the Internet of Things(IoT) and smart manufacturing, enhancing efficiency and connectivity in the transportation sector.

South Korea:

1. Technological Leadership: South Korea has rapidly emerged as a global technological powerhouse. Companies such as Samsung and LG have become synonymous with innovation not only in consumer electronics but also in the automotive sector. The country's technological prowess includes electric vehicles, autonomous systems, and smart-city solutions.
2. Government Support and Vision: The South Korean government has been proactive in supporting and guiding the development of the country's mobility sector. Strategic investments in R&D and infrastructure projects combined with a clear vision of the future have propelled South Korea to the forefront of mobility innovation.
3. 5G Connectivity: South Korea was one of the first countries to deploy 5G networks widely, providing a solid foundation for the development of connected and autonomous vehicles. The high-speed, low-latency capabilities of 5G are essential for real-time communication between vehicles and the surrounding infrastructure.
4. Smart City Initiatives: South Korea has embraced the concept of smart cities by integrating technologies to enhance the quality of urban living. These include intelligent transportation systems, efficient public transportation, and data-driven solutions for urban planning, which contribute to a more sustainable and interconnected mobility ecosystem.

Both Germany and South Korea have leveraged their historical strengths, robust industrial bases, and proactive governmental initiatives to propel themselves to the forefront of mobility innovation. Their commitments to sustainability, advancements in technology, and holistic approaches to shaping the future of transportation have solidified their positions as global leaders in the mobility revolution. They are natural partners: Germany's emphasis on precision engineering aligns with Korea's focus on technological innovation, creating a synergy that can drive advancements in electric vehicles, autonomous driving, and other transformative technologies.

Furthermore, both nations recognize the importance of international collaboration in addressing global challenges. By pooling their resources and expertise, Germany and Korea can accelerate the development of mobility solutions that transcend geographical boundaries, thereby fostering a more interconnected and efficient transportation lanscape. This partnership not only promises to shape the future of mobility but also signifies a collaborative approach to addressing the complex challenges that lie ahead.

Current Themes in German Public Debate on Mobility Transformation

Eight pivotal issues, arguably the major focus points of the current debate in Germany, will shape the trajectory of this transformative journey.

Infrastructure Development lays the foundation for seamless integration of cutting-edge technologies. The discussions focus on the need for further investment in transportation infrastructure, including the expansion of electric vehicle charging networks, improvements in public transportation systems, and integration of smart technologies to enhance overall mobility efficiency.

While Germany has been promoting *Electric Mobility*, debates revolve around the pace of EV adoption, charging infrastructure availability, and the associated energy transition challenges. There have been discussions on incentivizing EV purchases and addressing concerns related to range anxiety.

Autonomous Driving Regulations have emerged as dynamic forces steering the nation towards a sustainable and intelligent transportation ecosystem. Balancing innovation with safety and ethical concerns has been a topic of discussion along with the potential economic and societal impacts of widespread adoption.

Environmental Impact Assessment(EIA) ensures that advancements align with ecological imperatives. Sustainability remains a key focus and debates often involve discussions of the environmental impacts of different mobility solutions. Questions about reducing emissions, promoting cleaner transportation, and addressing the ecological footprint of the entire mobility ecosystem are part of the ongoing discourse.

Urban Planning and Livability reflect a commitment to fostering urban environments that are not only technologically advanced but also socially enriching. Mobility transformation is closely linked to urban planning and its impact on quality of life in cities. Public debates involve discussions on designing urban spaces that prioritize pedestrians, cyclists, and public transportation, with the aim of creating more livable and sustainable urban environments.

Digitalization and Data Privacy challenges underscore the need to strike a delicate balance between innovation and safeguarding individual liberty. The integration of digital technologies into mobility has raised concerns regarding data privacy and cybersecurity. Public debates involve discussions on balancing the benefits of data-driven solutions with the protection of individuals' privacy and the prevention of potential misuse.

The pursuit of *Social Equity* amplifies the urgency of addressing the disparities in accessibility and benefits arising from mobility transformations. Debates often focus on how mobility transformations affect different socioeconomic groups. The discussions include ensuring that new mobility solutions are accessible to all and do not exacerbate existing inequalities in transportation access.

Finally, *Public Transportation Funding* is a linchpin in determining the inclusivity and efficacy of collective mobility solutions. Funding and support for public transportation initiatives are discussed in the context of creating more efficient, affordable, and attractive alternatives to private car ownership. Public debates involve prioritizing and allocating resources for public transit projects.

Project Structure

This joint publication by the Konrad-Adenauer-Stiftung Korea Office and the Korea Transport Institute(KOTI) provides an exemplary overview of the visions and approaches in Germany and Korea for their respective mobility transformations. Both are leading nations in terms of technological progress and necessary legal frameworks in this field; they have developed complementary instruments and ideas. The comparison is meant to illustrate the nexus of pathways leading to a comprehensive and sustainable mobility transformation by analyzing specific scenarios, utilizing practical experience, and extrapolating methodological models. The results will aid policymakers in both countries and beyond in crafting sustainable mobility transformation strategies in their own context. Further discussion of these results is intended to stimulate the mobility debate with cooperation partners, particularly in the Indo-Pacific region, and to offer inspiration for developing their own strategies.

To implement this collaborative project, teams of authors from Germany and Korea were commissioned to create articles based on key questions regarding the four agreed subtopics. Before the writing process, digital workshops for the experts involved were held in the first half of 2023. This platform enabled the authors to get to know each other, exchange ideas directly, and coordinate content. In October 2023, the author teams and other mobility experts from the region met in Korea to present and discuss the manuscript drafts. The deliberations then led to final contributions dealing with current approaches in government policies and strategies, technological questions, and challenges to implementing actual projects in cooperation with private and public actors, as well as to legal and institutional frameworks.

As a successful result of this process, this publication has become a nuanced tapestry of innovations and challenges shaping the future of transportation, and each of these texts contributes a unique thread to a broader intellectual fabric. The following summary of chapters provides a glimpse into the intellectual landscape covered in this publication.

In his introduction, Dr. Jaehak Oh of KOTI discusses the concept of mobility and its significance in shaping the future of society and the economy, emphasizing its distinction from traditional transportation by incorporating useroriented services and personalized transportation. This highlights South Korea's successful transportation policies and its potential to become a global economic powerhouse through mobility transformation. The text also addresses the impact on mobility of major megatrends such as the climate change crisis, the 4th Industrial Revolution, demographic changes, and the global pandemic and outlines three key directions for the great mobility transformation: automation, decarbonization, and the sharing of transportation modes. Additionally, it emphasizes the importance of creating a virtuous cycle and stable financing scheme for mobility transformation and provides insights into South Korea's transport development outcomes and the establishment of a mobility transformation ecosystem.

A team of German authors introduces the philosophies and strategies of mobility transformation in Germany, focusing on the regional innovation cluster Munich Cluster for the Future of Mobility in Metropolitan Regions(MCube). They provide an overview of the landscape of mobility transformation in Germany, including the EU's New Green Deal and the Efficient and Green Mobility Packages. Their study also examines the challenges facing the Munich region's mobility system and the policies and resources available to address them. The chapter describes MCube's mission, structure, and R&D activities, along with its guiding principle of "Miteinander Möglich Machen"(Together We Can Make Possible). Their contribution concludes with lessons and recommendations for regional mobility transformation and potential interregional and international exchanges of experiences and best practices.

A team of KOTI experts discusses South Korea's technological developments to facilitate mobility transformation, focusing on decarbonization through electrification, automation of mobility objects, and sharing and integration of mobility objects through Mobility as a Service(MaaS). The chapter highlights the country's goals, such as the introduction of personalized and integrated MaaS, development of electrification-related technologies, and implementation of autonomous-driving-based mobility services. The document also emphasizes the need for the establishment of governance systems, public-private partnerships, and the enactment and revision of laws to support the activation of integrated MaaS. Additionally, it addresses the challenges and opportunities associated with these technological advancements and provides insights into the status and prospects of mobility transformation in South Korea.

Building on insights and experiences gained while working at LG CNS, Younghun Lee and Hyocheol Park review the challenges faced by users in accessing multiple mobility and public transit service apps, highlighting the inconvenience and confusion caused by the need to install and operate numerous apps for different services. The authors emphasize the importance of creating a more seamless and user-friendly experience for accessing mobility services, particularly through public-private cooperation. They also stress the need for government support and the establishment of standards to improve the introduction of Korean-style MaaS(K-MaaS). Additionally, their text underscores the central focus on public transportation in K-MaaS and the initiatives and recommendations from both private institutions and government agencies to drive the successful implementation of K-MaaS while promoting universal transportation welfare and shared transportation.

Another German chapter, written by affiliates of the Institute for Climate Protection, Energy, and Mobility e.V.(IKEM), discusses the legal and institutional aspects of mobility transition in Germany, focusing on the development of the charging-point market, autonomous and connected driving, smart mobility, and MaaS. This chapter highlights the need for effective regulation to ensure market and pricing mechanisms, as well as the importance of international regulations for autonomous driving. It also addresses amendments to German passenger transportation law, emphasizing the introduction of new transportation forms and the challenges posed by alternative service models. Furthermore, it delves into the complications related to autonomous driving and the federal government's role in defining quality standards and supporting data holders. Additionally, it touches upon international climate protection laws and their impact on Germany's transport sector, emphasizing the need for drastic reductions in CO_2 emissions to meet global climate targets.

Overall, the chapter underscores the significance of legal and institutional developments in facilitating mobility transitions and addressing challenges in the transport sector.

Additional studies growing out of the following discussions on the findings presented in this first edition from Germany, Korea, and other countries, particularly in Europe and the Indo-Pacific, are welcome and encouraged and will be integrated into the digital publication platform.

The authors from MCube and IKEM have provided inspiring work from the German side. Their initiative and personal commitment made the compilation in this form possible in the first place. Their contributions were mirrored and complemented by work of remarkable quality by experts from KOTI, the University of Seoul, and LG CNS.

Special thanks go to KOTI under the leadership of its outgoing President Jaehak Oh for the joint work on the planning and implementation of this publication. The commitment and dedication of Youngho Kim and Sunghoon Kim are particularly noteworthy.

On the part of the Konrad-Adenauer-Stiftung, recognition for the development of our cooperation and coordination of the entire work process goes to my highly valued colleagues YuJin Song and Patrick Schweiß, as well as the other members of our office team for their continuous support.

This text was written using generative AI.

The Direction and National Strategies for the Great Mobility Transformation

Dr. JaeHak Oh
President | Korea Transport Institute

The concept of mobility and the meaning of the great transformation

KONRAD ADENAUER STIFTUNG

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The concept of mobility

Recently, the concept of "mobility" has become prominent in discussions of society and the economy. The 110 Key Policy Tasks[1] announced by the Yoon Suk-yeol administration in May include "the opening of the era of mobility and the future strategic industrialization of the land and transport industry." This agenda aims to support agricultural innovation and economic growth through mobility innovation, with a focus on the commercialization of autonomous vehicles, urban air mobility(UAM), and the establishment of electric hydrogen vehicle clusters. Mobility is expected to be a concept that will reshape the future of society and the economy beyond the transportation sector.

Transportation is a concept that encompasses the movement of people and goods, as well as vehicles, transport infrastructure, operating entities, and transportation policies necessary for that movement. By contrast, mobility is a relatively recent concept that adds user-oriented services to the traditional notion of transportation. While existing transportation policies and research mostly adopt the perspective of transportation providers, mobility differs in that it is discussed from the perspectives of transportation users or consumers. Another distinctive aspect of mobility is its emphasis on providing transportation as a personalized service.

The meaning of the great mobility transformation

The growing importance of and interest in mobility portends a period of great transformation over the next 10 years. South Korea is the only nation that has achieved unprecedented economic development over the past half century with successful transportation policies at its core. South Korea's transportation policies have been implemented in three main ways:

1) developing the automobile industry into a powerhouse;
2) improving the quality of life for citizens through timely investment and the establishment of social overhead capital(SOC); and
3) implementing transportation policies with a focus on public transport in metropolitan areas.

However, at present, mobility is directly influenced by four major megatrends: the climate change crisis, the 4th Industrial Revolution, demographic changes, and the global pandemic. Mobility is expected to

1 Presidential Transition Committee for the 20th President-elect, "110 Key Policy Tasks of the Yoon Seok-yeol administration.

undergo significant changes, depending on how these challenges are addressed and overcome. By taking the lead in successfully executing changes in mobility, South Korea can also become a global economic powerhouse. From this perspective, mobility transformation has three key implications.

First, the mobility transformation will be the greatest change in transportation since the Industrial Revolution of the 18th century. This change is based on the hyperconnectivity/hyperconvergence of the 4th Industrial Revolution and is expected to be driven by information and communication technology(ICT). In particular, the utilization of ICT is essential in areas such as the commercialization of autonomous vehicles(AVs), UAM, and smart logistics, all of which are based on digital infrastructure. This is expected to bring about complex changes in the industrial ecosystem due to the growth of related industries.

Second, mobility transformation will bring about changes in employment. Many jobs related to transportation are expected to be affected either directly or indirectly by mobility transformation. The demand is expected to increase for occupations related to AVs, green vehicles, and mobility services; however, it is necessary to seek ways to address employment shocks preemptively in occupations where jobs are expected to decrease, such as the production of internal combustion engine vehicles.

Third, the mobility transformation is a solution for transport externalities. Relying solely on demand-restraint has limited the ability to solve externalities such as traffic safety issues, traffic congestion, and environmental pollution caused by the rapid increase in the use of automobiles. In 2013 in South Korea, traffic accident costs amounted to approximately 43 trillion won(2.25% of the GDP); traffic congestion costs were approximately 70 trillion won(3.67% of the GDP) as of 2019[2] ; and transport environment costs[3] were approximately 30 trillion won.[4] However, the mobility transformation is expected to help solve transport externalities that could not be solved in the past, due to changes in transport means and the advent of various innovative technologies.

2 Korea Transport Institute (2022), "2021 Traffic Policy Evaluation Index Survey Project." pp.3, 6.

3 This is the sum of air pollution, greenhousegas, and noise costs. Air pollution and noise costs are the sum of road and rail, and greenhouse gas costs are the sum of the road, rail, maritime, and air.

4 Korea Transport Institute (2017), "2016 Korea Transportation Statistics," pp.269–271

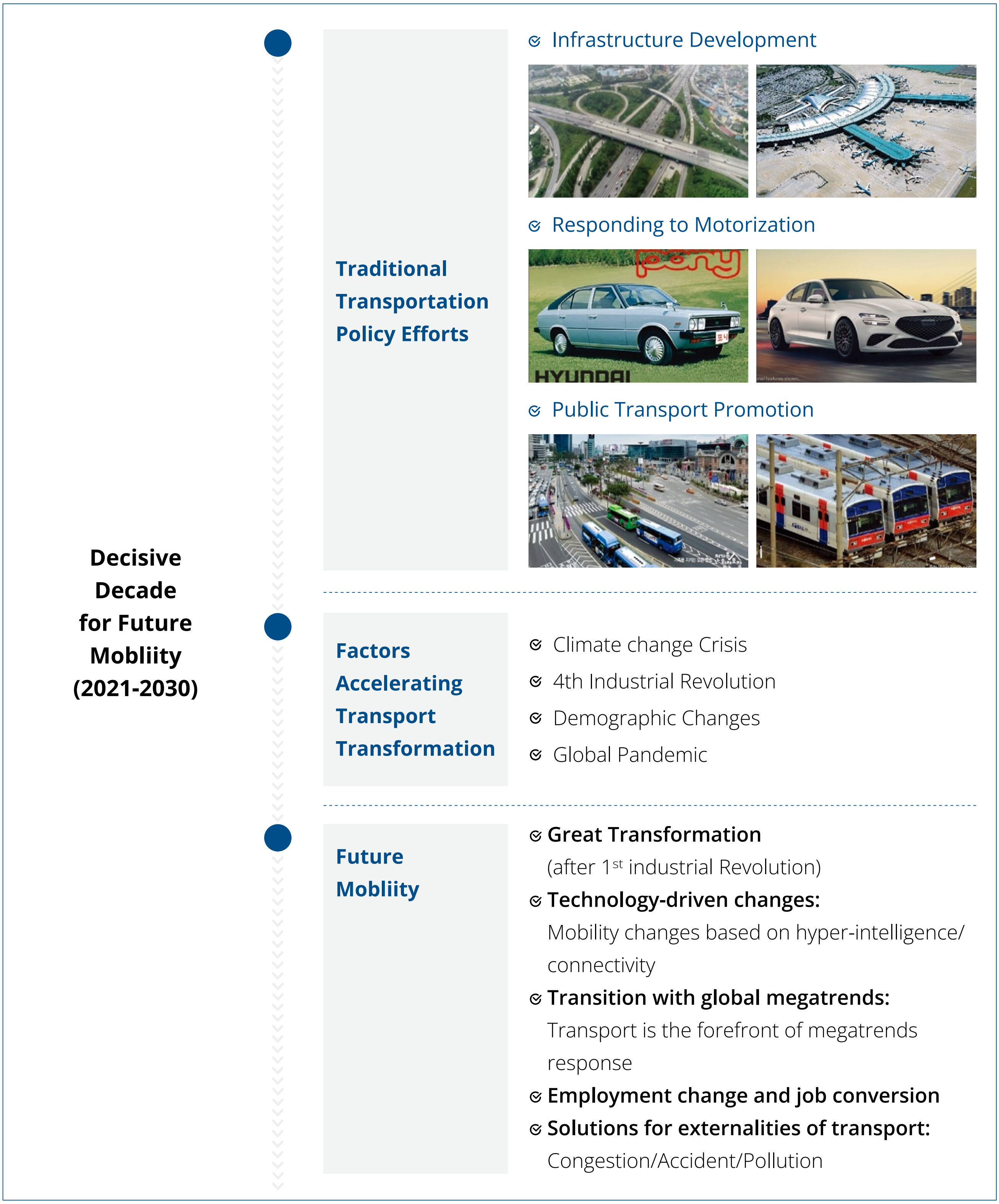

Figure 1. The meaning of mobility transformation

Megatrends in economy, society, and science and technology and mobility transformation

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transformation

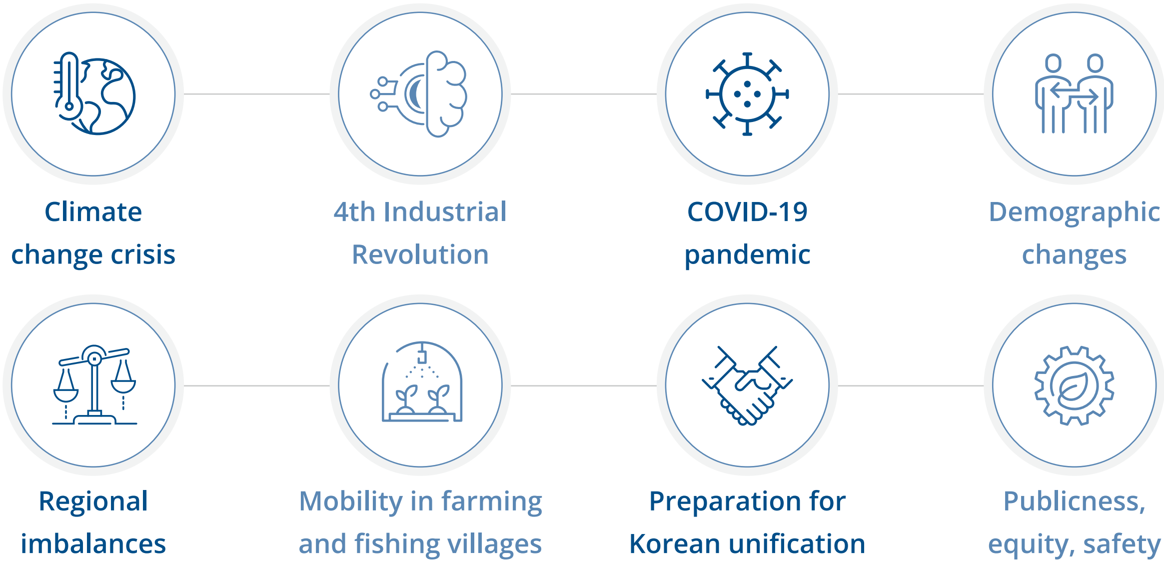


Figure 2. Megatrends in the economy, society, and science and technology

Megatrends in the economy, society, and science and technology, such as the climate change crisis, the 4th Industrial Revolution, the COVID-19 pandemic, demographic changes, and regional imbalances, are directly and indirectly related to economic and social sectors. These megatrends provide momentum to transform society; the transportation sector, in particular, is directly influenced by these trends. Global megatrends that directly affect the transportation sector include the climate change crisis, progress in science and technology, demographic changes, and the COVID-19 pandemic. For example, social distancing measures proposed as a solution to the pandemic decreased transportation demand.

Climate change crisis

As of 2018, there were approximately 35 billion tons of CO2eq (greenhouse gas emissions) worldwide, of which 700 million tons were discharged in South Korea.[1] Although this is a small percentage of the global total(approximately 2%), South Korea emitted approximately 3.18 tons of CO2eq in 2020, which ranked second-highest among G20 members after Australia(4.04 tons). This is approximately three times higher than the global average(1.06 tons).[2]

1 Excerpted from Our World in Data (https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions, accessed on: Apr. 10, 2022)

2 Pressian (May 20, 2022), "Korea is the world's No. 2 climate villain: Per capita greenhouse gas emissions from coal-fired power generation surpassing China and the United States." (https://www.pressian.com/pages/articles/2022052014435720546?utm_source=naver&utm_medium=search, accessed on: Apr. 10, 2022).

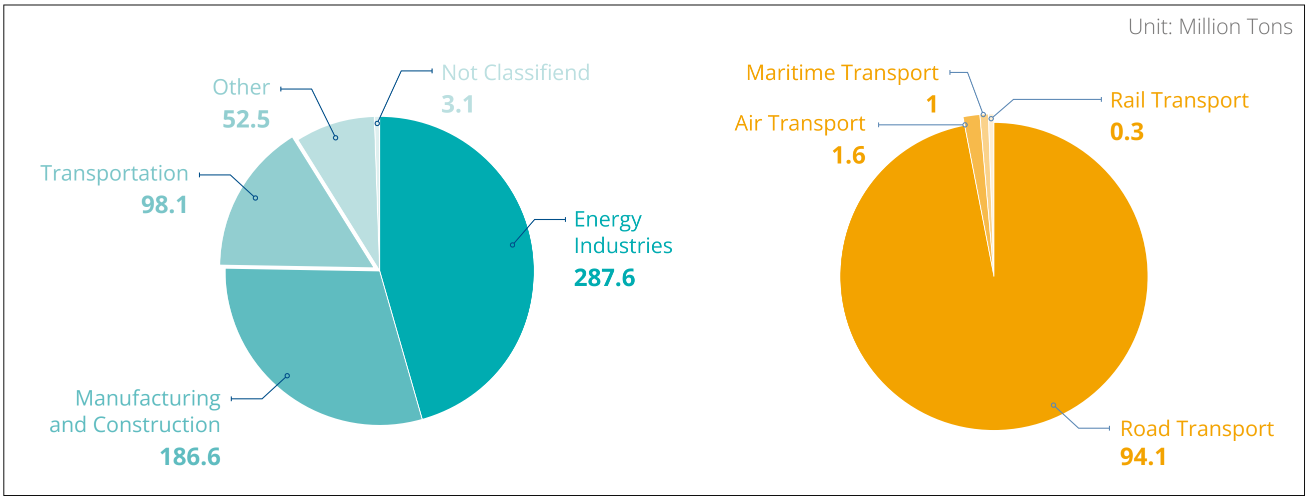


Figure 3. Greenhouse gas emissions in South Korea(2020)

Source: Ministry of Environment(2020), "2020 National Inventory Report," 127 p. reorganized.

The transportation sector accounts for approximately 13%(98 million tons) of South Korea's total greenhouse gas emissions. As shown in Figure 3, most greenhouse gas emissions in the transportation sector originate from road transport(94%), followed by air(1.6%), maritime(1%), and rail(0.3%).[3]

Since announcing the "2050 Carbon Neutrality" in December 2020, South Korea has been taking active measures to deal with the climate change crisis by proposing the "2030 Updated NDC"[4] and "2050 Carbon Neutrality Scenarios" in October 2021. The goal in the transportation sector is to reduce greenhouse gas emissions by approximately 40% from 2018 levels by 2030 and by more than 90% from 2018 levels by 2050,[5] [6] which indicates that mobility transformation aligned with carbon neutrality scenarios will be inevitable in the transportation sector.

Progress in science and technology

The 4th Industrial Revolution has spurred the development of ICT, such as artificial intelligence(AI), the Internet of Things(IoT), big data, and the cloud, leading to the proliferation of innovative technologies based on hyperconnectivity and hyperconvergence. In the transportation sector, there are plans for Level 4 autonomous driving by 2027 and UAM commercialization by 2025, which are expected to drive the active development of related technologies. Additionally, there is a need to create cooperative intelligent transports systems(C-ITS), high-

3 Ministry of Environment (2020), "2020 National Inventory Report," p. 127.

4 Nationally Determined Contribution(NDC)

5 Carbon Neutrality and Green Growth Commission (2021), "2030 Updated NDC."

6 Carbon Neutrality and Green Growth Commission (2021), "2050 Carbon Neutrality Scenarios."

definition road maps, and vertiports. It is also necessary to establish legal and institutional frameworks to facilitate the proliferation and commercialization of related technologies. Progress in science and technology may determine the success or failure of the great mobility transformation, as it is ultimately expected to resolve the externalities of transport, such as traffic safety issues, congestion, and environmental pollution.

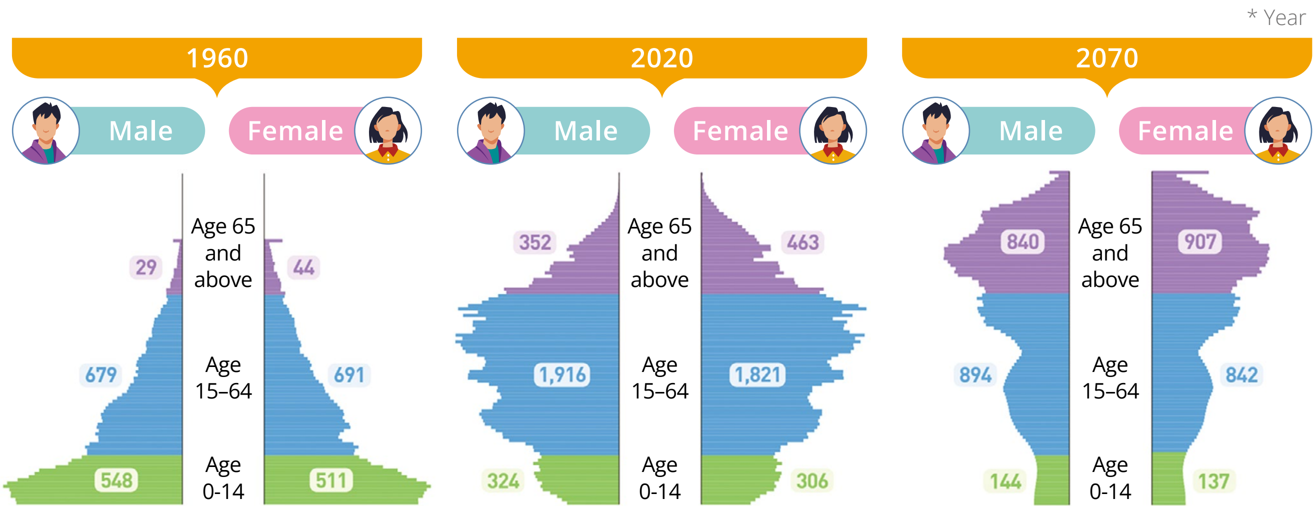
Demographic changes

South Korea is rapidly becoming a super-aged society, which is expected to result in population decline due to low birth rates. According to Statistics Korea,[7] South Korea's population is expected to decrease from approximately 51.84 million in 2020 to 37.66 million by 2070. Furthermore, the working-age population and the old-age dependency ratio are expected to become similar by 2070. The OECD has also forecasted that by 2060, South Korea will have the highest old-age dependency ratio among OECD member countries.[8]

Demographic changes are easier to predict than other megatrends based on which measures can be established in advance. Mobility issues that may arise due to demographic changes in South Korea include a decrease in transportation demand, an increase in traffic accidents among the elderly, and a regional imbalance in transportation services. Mobility transformation must be carried out in a way that can resolve

7 Statistics Korea Press Release(Dec. 9, 2021), "Population Projections for Korea: 2020–2070," pp. 8–27

8 OECD(2020), "OECD Economic Surveys Korea," pp. 10-11.



Source: Statistics Korea Press Release(2021. 12. 9), "Population Projections for Korea: 2020~2070," p. 6.

Figure 4. Changes in population pyramids by year.

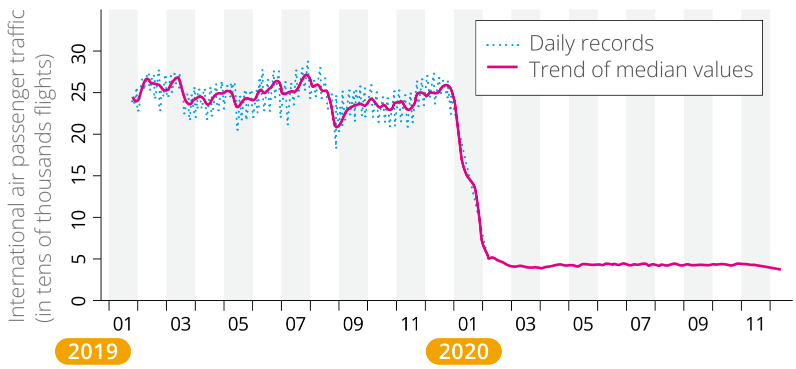
related issues.

Global pandemic

The unprecedented COVID-19 pandemic has caused significant damage to societies and economies worldwide, and most measures taken to prevent the spread of this infectious disease have restricted the movement of people and goods, resulting in a sharp decrease in transportation demand. According to an analysis by the Korea Transport Institute,[9] the COVID-19 pandemic reduced inter-regional highway traffic in 2020 by approximately 2.8% compared with 2019. It reduced inter-city bus and rail traffic, which are public transportation services, by approximately 40%–50%. By mode of transportation, air transport was hit hardest by COVID-19, as passenger demand decreased by 23.8% for domestic flights and by 84.3% for international flights in 2020 compared with 2019. In contrast, there was a noticeable increase in the demand for public bicycles, which amounted to approximately 20% in 2020 compared with 2019. Furthermore, according to an analysis by McKinsey,[10] users chose modes of public transportation based on travel time before the COVID-19 pandemic, but now choose modes based on the Risk of infection diseases. As the COVID-19 pandemic has transitioned toward the endemic phase, its impact on transportation has diminished. However, the changes in the travel behavior of users caused by COVID-19 will likely persist, becoming a new normal in the transportation sector. Therefore, the mobility transformation must address not only the recovery of transportation demand after the pandemic but also the travel behavior of users.

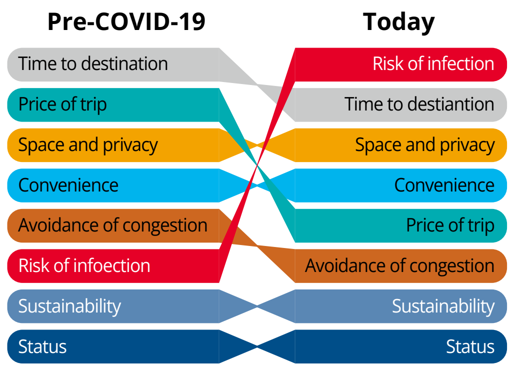
9 Korea Transport Institute (2021), "2021 Transport Logistics Development Index Forecast(Passenger Travel Index)," pp.3–15.

10 McKinsey(2020), "Five COVID-19 aftershocks reshaping mobility's future."



Source: Korea Transport Institute(2021), "2021 Transport Logistics Development Index Forecast(Passenger Travel Index)", 10 p.Source:

Figure 5. Daily international air passenger traffic



Mckinsey(2020), "Five COVID-19 aftershocks reshaping mobility's future"

Figure 6. Mode selection factors

Three key directions for great mobility transformation

Mobility transformation will be made by focusing on three key directions:

1. automation that will lead to the gradual disappearance of drivers;
2. decarbonization, such that the transportation system shifts from relying on fossil fuels to renewable energy; and
3. sharing of transportation modes rather than ownership, supported by consumer-centered integrated services and supply centered transportation policies.

Automation

In South Korea, the commercialization of AVs and UAM is progressing. First, for autonomous vehicles, efforts are being made to accelerate the development of driving technologies and the demonstration of services with the goal of commercializing Level 4 AVs by 2027. In addition, the C-ITS is being established through a pilot project by the Ministry of Land, Infrastructure, and Transport in an attempt to build a digital infrastructure, and there are plans to complete the construction of high-definition maps for all national roads by 2030. The commercialization of AVs and the establishment of digital infrastructure are expected to increase transportation capacity and reduce traffic accidents. However, the decrease in employment in the automobile manufacturing and transport industries and accident liability remain as challenges that must be addressed. For UAM, the UAM Team Korea, which is comprised of industry, academia, and research institutes, has been formed to pursue technological competitiveness with the goal of commercialization by 2025. The world's first demonstration of UAM operation and control was conducted in November 2021. If UAM is commercialized, users can expect reduced travel time, and the industry can provide mobility services that do not yet exist. However, there are intense conflicts over infrastructure-related issues such as the selection of vertiport locations, corridor conflicts with existing helicopters, and airspace operations. In particular, improving public acceptance through social consensus in terms of safety and cost is a prerequisite for the successful commercialization of UAM

Decarbonization

Decarbonization for mobility transformation will be carried out based on "2030 Updated NDC" and "2050 Carbon Neutrality Scenarios." The main measures to achieve carbon neutrality in the transportation sector can be broadly categorized as managing transportation demand, expanding the adoption of green vehicles, and creating a market environment.

Carbon neutrality through transportation demand management primarily involves reducing the demand for private cars and increasing the use of public transportation and Personal Mobility (PM). Specific measures include enhancing the convenience of public transport through improved intermodal transportation, expanding the use of PM such as bicycles and kickboard scooters, strengthening the railway-centered transportation system, and utilizing rail and maritime transport for freight transportation.

Strategies to increase the supply of green vehicles include increasing the number of electric and hydrogen vehicle charging stations, replacing overage vehicles at an early stage, and converting commercial vehicles first. Although there has been little progress, 1.15 million green vehicles and 230 thousand electric vehicles have been supplied, and 72 thousand electric vehicle charging stations were built in 2021.

Finally, measures to create a market environment for carbon neutrality include the imposition of transportation, energy, and environmental taxes; a national subsidy system; an emissions trading scheme; and an automobile carbon point system. Subsidies for purchasing of electric vehicles are increasing every year, but the public is not fully aware of these measures.

Sharing/integration

Shifts in public perception have led to a rapid increase in the use of car-sharing services, and various sharing services have emerged. However, in South Korea, as the Passenger Transport Service Act was amended in 2020, due to the conflict between shared transport services and the existing transport industry, the focus of sharing has been on sharing vehicles only instead of rides.

Integration refers to 1) meeting user demands, 2) using sustainable methods, and 3) providing seamless transportation services by operating transportation and establishing infrastructure. This transportation integration aligns with the construction of smart cities, and Mobility as a Service(MaaS) is expected to be test in national pilot smart cities like Sejong 5-1 Living Area and Busan Eco Delta City.

Sharing and integration are undoubtedly important transition directions in terms of mobility, in that they can provide demand-responsive services and reduce the burden of cost for users. However, it is challenging to find ways to coexist with the existing transport industry. It is necessary to establish flexible strategies to minimize side effects such as the weakening of the automobile industry due to reduced car ownership and decreased public transport ridership.

	Automation	Decarbonization	Sharing/Integration
Transformation details	Active demonstration projects such as autonomous cars and drones Uncertainties in practical use and commercialization Robotaxi vs. Advanced Driver Assistance System(ADAS)	2030 Updated NDC Finalized 2050 Carbon Neutrality scenarios Low supply of electric vehicles, hydrogen vehicles, etc.	Increased demand for car sharing Difficulty in providing ride sharing service Increased demand for PM due to COVID-19
Anticipated outcomes	Increased transportation capacity Decreased transportation accidents Reduced commuting time and social costs	Fulfilment of carbon neutrality: Electric vehicles and hydrogen vehicles produce almost no exhaust gas emissions or noise Securing relevant technological competitiveness	Increased user convenience: Demand-responsive service provision, user cost reduction Increased land use efficiency
Key issues	Decreased jobs: Decreased employment of workers in existing automobile manufacturing and transport industries dentifying responsibility in case of safety issues and accidents	Adequate supply of electric vehicles and hydrogen vehicles: Electric vehicles – small cars Hydrogen vehicles - large vehicles and public transportation Charging station and battery issues	Decreased number of cars owned Decreased number of public transportation users Conflict with the existing transport industry

Figure 7. Daily international air passenger traffic.

National strategies for great mobility transformation

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South Korea's transport development outcomes

South Korea is the only country that has built transportation infrastructure comparable to that of advanced countries in such a short time, during the period of rapid economic growth over the last half century.[1] South Korea's transport infrastructure is the envy of many countries worldwide and serves as a great benchmark. Transportation in South Korea has developed in a virtuous cycle with the economy.

Factors contributing to South Korea's transportation development include 1) timely investment and expansion of infrastructure, 2) transportation policies centered on public transportation, and 3) the establishment of a stable financing scheme. Generally, it takes a significant amount of time and investment to build transport infrastructure. Stable financing is a prerequisite to ensure that infrastructure construction keeps pace with economic development. South Korea was able to secure financial resources for investment in transportation infrastructure through special accounts for transportation facilities. Transport development was enhanced by a virtuous cycle that included increasing the number of cars owned, entering the world's top five automobile-producing countries, and expanding the 7 × 9 grid national road network. Establishing a convenient road network promoted car ownership and use, which secured fuel tax revenue, allowing for stable financing for the construction of transport infrastructure, as shown in Figure 8.

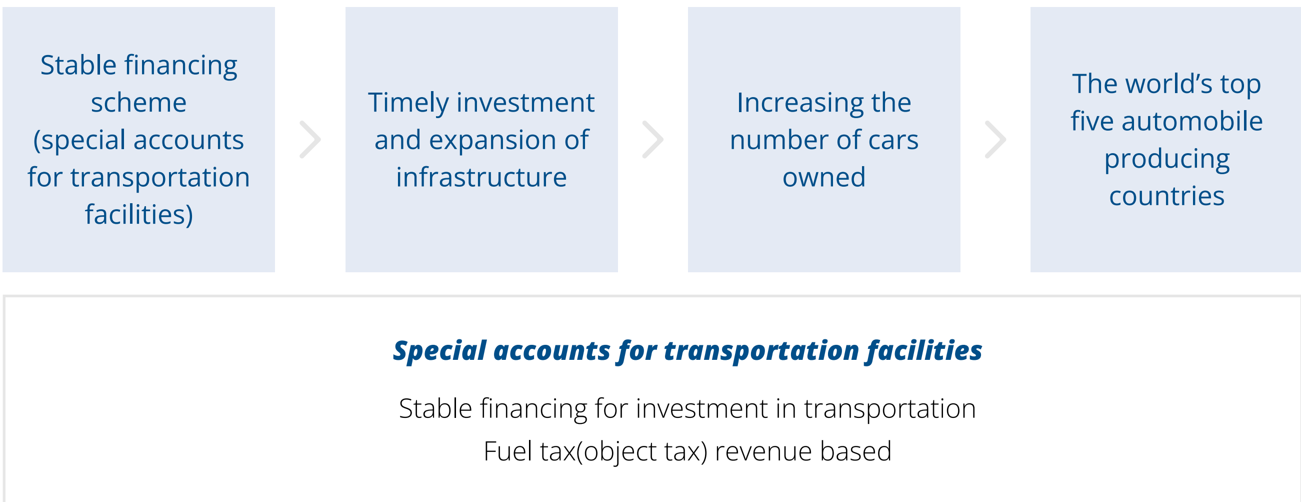


Figure 8. South Korea's transport development model.

1 Seoul Shinmun(May 10, 2018), "Korea's Transport Development Model" (https://www.seoul.co.kr/news/newsView.php?id=20180511029004, accessed on: Apr. 14, 2022)

Establishment of a mobility transformation ecosystem

To achieve mobility transformation, it is important to create a virtuous cycle of various elements such as the transportation development process in South Korea. Mobility transformation has a complex structure, in which the automobile industry, digital infrastructure, mobility services, related regulations, and systems influence and even lead each other. Mobility transformation cannot be achieved by excelling in a specific area or by leading other industrial sectors. Instead, it is essential to build a mobility transformation ecosystem in which the components can coexist through cooperation.

Key policy issues related to mobility transformation

The mobility transformation ecosystem consists of complex relationships between government, industry, technology, and stakeholders, which is why various issues must be resolved for mobility transformation. Therefore, it is necessary to examine the key issues for each element of the mobility transformation ecosystem.

First, as internal combustion automobiles are replaced by green vehicles and AVs, there is a risk that the existing automobile industry will collapse, which would cause significant unemployment. However, the new automobile industry could create new jobs, and it may be possible to secure competitiveness in related technologies through mobility transformation.

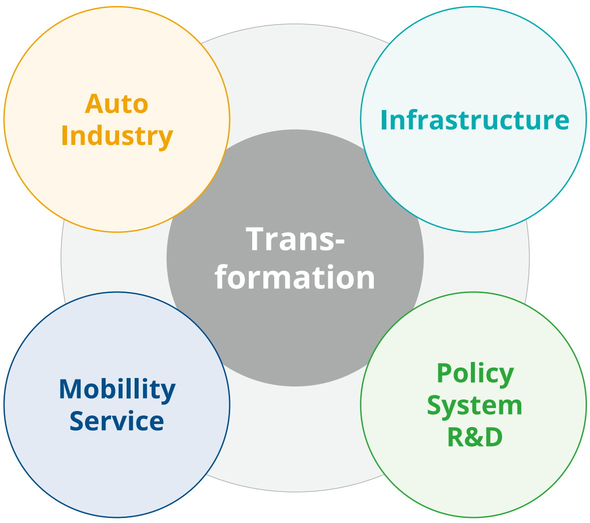
The digital infrastructure for successful mobility transformation includes both hardware and software. It is the most basic element for the mobility transformation ecosystem to create a virtuous cycle. Financing is essential for establishing digital infrastructure concurrently with other elements of mobility transformation, which is directly related to the issue of tax system reform. Moreover, the government must lead the construction of a unified nationwide digital infrastructure construction that ensures data security.

Next, it is necessary to improve the elements that help the early proliferation and settlement of other elements of the ecosystem, such as institutional reform, system development, and R&D related to mobility transformation. New and old regulations must be harmonized so that the transformation can be made naturally, and the roles of government, industry, and academia must be clarified. Other important issues include establishing a social safety net for workers in industries where employment is decreasing and to protect new occupations.

Finally, mobility service is the element that is most closely connected to users, as well as the most important element of mobility transformation, as it changes people's perceptions and increases their acceptance of new forms of mobility services. Newly emerging mobility services may cause conflicts with existing industries; however, at the same time, mobility services may increase user convenience and resolve regional mobility imbalances.

- Collapse of ICE automobile industries
- Decrease in old labor force and demand in new workforce
- Technological competitiveness for autonomous and electric vehicles

- 3D digital map, C-ITS, control center, V2X, drone airspace control
- Financing infrastructure digitalization
- National plan for infrastructure digitalization



- Conflict with existing industries(taxi)
- Rise of platform-based enterprises
- Public compliance
- Improving the gap in mobillity service between urban and rural areas

- Reforming regulations
- Enhancing the role of national R&D
- Assigning roles among government, industry, universities & institutes
- Enhancing social safety net and Employment romotion

Figure 9. Key policy issues related to mobility transformation.

National policies for successful great mobility transformation

For a successful mobility transformation, industries, technologies, social safety nets, and employment must work together in the transformation ecosystem to form a single market, which will exert a positive impact on other components in a virtuous cycle. Thus, the transformation ecosystem must be market-based rather than government-led, and there is a need for demonstration projects and services that the public can experience to expand the mobility industry. Public acceptance of these initial changes will accelerate the mobility transition. In this virtuous cycle, automation, decarbonization, and sharing/integration must be achieved simultaneously within a single framework, which must be accompanied by the establishment of a social safety net and education and training of human resources to stabilize employment.

Goals	Strategies
Economic efficient, Eco-friendly, Inclusive Mobillity Service	Establishment of National Strategy for Market-Based Transformation Ecosystem
Technology innovation + Economic efficiency + Social inclusion + Sustainabillity	The 3 Revolutions should be processed in a from of simultaneous transformation
Zero Emission, Zero Casualty, Affordabillity	Successful transformation should be based on social agreement between stakeholders
	Support demonstration projects for the creation of mobillity services felt by the public
	Social security net and training of new workforce should be put into a top priority

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Moving Forward:

Transforming Mobility in Germany through the Regional Innovation Cluster "MCube"

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Introduction

The International Automotive Exhibition(IInternationale Automobilausstellung, IAA) took place in Munich in September 2023. Several prominent spots and public places in Munich featured exhibitions by established and newly emerging firms showcasing their visions of the future of mobility and transportation - how we might move and live. In addition to the exhibitions and booths within the city center, the IAA Summit and Conference at the Messe München(Trade Fair Munich) targeted a professional audience, including leading businesses, stakeholders, visionaries, and decision-makers. The event hosted more than 750 exhibitors and 500,000 visitors worldwide, leading the organizers to claim, "this year's IAA Mobility 2023 was a great success."

In 2023, Munich hosted the IAA for the second time since 2021. Long hosted in Frankfurt, the IAA had become one of the world's most important trade shows for cars. This change in location has been accompanied by an effort to reframe the event from an exhibition for automobiles to a mobility platform, featuring a variety of transportation forms, including active mobility and digitized services. As it is stated officially on the IAA website: "The German automotive industry is confident and shows determination - we are ready for the challenges of the future. We are confident that our innovations will set the standards in global competition. The IAA MOBILITY is a signal of departure, the automotive industry is showing the strength of will and the innovative ability it needs to turn the transformation into a joint success story. That is the spirit that goes out from Munich into the world."[1]

This addresses the global challenges of transformation and the specific challenge facing Munich, a significant car-manufacturing location in Germany's "automobile nation"(Wentland 2017), as it tries to reinvent itself and secure a spot in a future global economy. Transformation is a keyword in this effort, and it seems inevitable that neither global challenges, such as climate change, nor Germany's or Munich's position can be maintained without such change. The IAA presented itself as a response to this demand and as "determined to inspire society with our solutions and motivate them to make their contribution on the road to climate-neutral mobility."[1] The event featured bikes and pedelecs that could be tested in Munich's largest park, the "Englischer Garten," and a participatory format, favoring "open dialog and constructive exchange with the public."[1] For example, the Citizen Lab at Munich's Marienplatz hosted 65 panels on different topics, some of which were

1 https://www.iaa-mobility.com/de/newsroom/news/leitthemen/iaa-mobility-2023-begeisterung-halbe-million-besucher (retrieved: Nov 30, 2023)

shaped by the Munich Cluster for the Future of Mobility in Metropolitan Regions(MCube), this chapter's case study.

The IAA has been associated with common narratives that treat technological innovation as a driver of economic growth, competitiveness, and prosperity. Maintaining these narratives elicited criticism and protests before and after the event. Despite, or perhaps because of, these efforts at rebranding, the activist group No Future IAA called the exhibition a "greenwashing-promo-event of the automobile industry" and organized demonstrations to raise awareness of their concerns while all eyes were on Munich. The activist group stated that IAA "carries the fairy tale of climate-neutral digitized and electrified mobility into the world" and that rather than smart or electric mobility, what we need is "a new concept of mobility, a new concept of city, a rethinking of space."[2] The group was already active in 2021. In 2023, the protests garnered more media attention. Leading up to the event, the media focused on "Letzte Generation"(translated: last generation), a climate activist group known for their unconventional protests against private automobiles, the space they take up, and their environmental consequences. In a large Munich park, around 900 activists set up the "Mobilitätswende Camp"(translated: Mobility Transition Camp) to protest for an alternative future of mobility. They held an alternative program that included workshops and talks.

We decided to tell this brief story of the IAA conflict in Munich not only to document a case of debate over the way we should move in the future but also to reveal fundamental questions regarding the mobility transformation in Germany and Munich. These questions are crucial to understanding visions, strategies, decision-making, and conflict in a specific region. The clashing positions illustrate the stakes in mobility innovation and transformation: whose visions and values will guide choices; who has the power, authority, and resources to shape them; and how should public space be allocated? The implications range from the individual(e.g., which places I can access) to the local(e.g., public transport infrastructure) and global(e.g., global warming) levels.

Germany is facing mobility challenges that national and regional levels seek to address while providing sustainability, economic competitiveness, technological novelty, and a livable future for the coming generations. However, despite these efforts toward transformation, mobility innovation is fragmented in practice, failing to provide durable solutions

2 https://nofutureiaa.noblogs.org/ (retrieved: Nov 3th, 2023)

for a sustainable future. The current system must be radically reshaped if sustainable mobility is to become a reality. At the same time, it is difficult to let go of a system that has been established for a long time. Systemic change requires a strong vision and sustainability goals, with clear targets that are taken seriously and are binding for all governing bodies. Science can highlight potential pathways for change, and decision makers can use this knowledge to decide which parts of the system should be preserved and which should be changed. At the same time, this transformation challenges privileges and raises questions regarding justice. Who may maintain a potentially unsustainable lifestyle and at what price? Who should take responsibility for achieving the sustainability goals? Transforming mobility changes routines, which creates a need to inform citizens, take their concerns seriously, and ensure their support.

Through the case study of MCube, we will illustrate how a systemic, regional approach can address the challenges of the mobility transformation. In particular, we will introduce MCube's guiding principle "Miteinander Möglich Machen"(translated: together we can make things possible) as an expression of a regional, participatory, and co-creative approach to mobility innovation. We show how this can serve as a scalable example of innovation processes for other regions in Germany and worldwide. MCube is one of seven R&D-clusters funded by the Federal Ministry of Education and Research via their initiative "Clusters4Future"; it consists of fourteen individual research projects, ranging from engagements with automotive driving and electrification to reflection on mobility justice and the reshaping of city quarters through living laboratories and test beds.

The chapter proceeds as follows. First, we provide an introduction to the landscape of mobility innovation in Germany, including the strategies, policies, and initiatives that frame the activities of MCube in its national context. Building on this, we review the regional challenges that have arisen in Munich's mobility system and the city's resources and policies. In Section 4, we examine the MCube Cluster case. We describe its vision, mission, structure, and R&D activities. We consider how its guiding principle, "we make things possible together," has been implemented to achieve a forward-looking approach to mobility transformation.

The Landscape of Mobility Transformation in Germany

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Mobility Strategies at EU Level

In recent years, Europe has undergone a significant paradigm shift with the introduction of the New Green Deal. This initiative was spearheaded by the EU Commission President Ursula von der Leyen and aims at achieving climate neutrality for the 27 European Member States by 2050. This ambitious plan intends to transform the EU into a modern, resource-efficient, and competitive economy. After decades of unilateral emphasis on motorized transportation and its industry, the "new EU Urban Mobility Framework" was introduced in December 2021 as part of the wider “Efficient and Green Mobility Package.” The framework aligns with the European Green Deal by supporting the transition to cleaner, greener, and smarter mobility. Its proposals to modernize the EU's transport system include enhancing connectivity; promoting rail and inland waterways for passengers and freight; supporting the expansion of charging points, alternative refueling infrastructure, and digital technologies; emphasizing sustainable urban mobility; and facilitating efficient multimodal transport options. These proposals aim to reduce the transport sector's emissions by 90%.

Furthermore, a significant milestone was achieved in 2023 with the introduction of the "European Declaration on Cycling," elevating cycling policy to a new level and providing coherent policy support across EU Member States. This declaration included eight principles with 36 commitments to foster a successful cycling ecosystem for society and businesses. These principles include developing cycling policies, encouraging inclusive and affordable mobility, enhancing cycling infrastructure, increasing investments, improving road safety, supporting green jobs and the cycling industry, promoting multimodal and cycling tourism, and enhancing cycling data collection.

Mobility Policy at the German National Level

In June 2023, the German government launched a new version of the Climate Protection Act with the goal of achieving greenhouse gas neutrality by 2045. In conjunction with the Climate Protection Act, a Climate Protection Program was launched, which included specific measures by the Federal Government to adhere to climate targets. The program sets targets and provides measures to achieve greenhouse gas emission reduction across sectors, including transportation, by promoting alternative fuels, expanding the charging infrastructure for electric vehicles, and increasing the share of public transport and cycling(Bundesregierung 2023). Another cornerstone in Germany's mobility policy was the "Nationale Platform Zukunft der Mobilität" (NPM, translated as National Platform Future of Mobility), a forum to discuss "strategic course-setting in the mobility sector."[1] Members of the NPM were appointed in 2018 by Andreas Scheuer, the Minister of Transportation. The NPM brought together representatives from the government, industry, academia, and civil society to develop a comprehensive vision and action plan for the future of mobility in Germany. The NPM aimed to make Germany a global leader in sustainable mobility by focusing on decarbonization, digitalization, and social responsibility. Specifically, NPM targets included developing cross-modal and interlinking solutions for a largely greenhouse-gas-neutral and environmentally friendly transport system, ensuring a competitive automotive industry, promoting Germany as a center of employment, and enabling efficient, high-quality, flexible, safe, and affordable mobility. The NPM proposed measures such as increasing the share of renewable energy in the transport sector to 28% by 2030 and establishing a national mobility data platform(NPM 2020). The NPM ended in 2021 at the close of Germany's 19th legislative period.

In summary, the four defining features of Germany's national strategy are as follows. First, the focus is on sustainable urban mobility and the development of livable, low-carbon cities. This emphasizes the importance of integrated public transportation, active transportation (cycling and walking), and shared mobility. This strategy aims to reduce car dependency, improve air quality, and enhance the overall quality of life in urban areas. Second, the national strategy recognizes the potential of digital technologies to transform mobility. Data-driven mobility solutions, intelligent transportation systems, and digital platformscan enhance efficiency, optimize traffic flow, and improve user experience. Third, the national strategy emphasizes the importance of research and innovation in shaping mobility. It supports funding for research projects, collaboration between industry and academia, and the development of cutting-edge technologies and solutions in areas such as autonomous driving, smart mobility, and battery technology. Fourth, the national strategy recognizes the need for socially and environmentally responsible mobility solutions. It aims to ensure accessibility, affordability,

1 https://www.plattform-zukunft-mobilitaet.de/die-npm/ (retrieved: Nov 30th, 2023)

and inclusivity in transportation by considering the needs of all segments of the society, including vulnerable groups. The strategy promotes sustainable and resource-efficient practices throughout the mobility value chain (Bundesregierung 2023).

Additionally, there is a range of programs and policies targeting specific areas of mobility. The "Bundesverkehrswegeplan 2030"(BVWP, translated as Federal Transport Plan) provides €270 million to reduce highway congestion, increase passenger and freight rail capacity, and add more economical transportation options on federal waterways (Bundesministerium für Verkehr und digitale Infrastruktur 2016). The "Sofortprogramm Saubere Luft 2017-2020"(translated as Instant Program Clean Air 2017-2022) provided €1.5 billion to municipalities with particularly high nitrogen dioxide(NO2) levels for remediation through the electrification, digitalization, and the retrofitting of diesel buses("BMDV - Sofortprogramm Saubere Luft" 2023). According to the Climate Protection Act, the German government is committed to increase the number electric vehicles(EVs) significantly. It includes targets such as having fifteen million EVs on the road by 2030 and expanding the charging infrastructure network to one million public and private charging points. The plan outlines measures to support research and development, manufacturing, and consumer incentives to accelerate the transition to electromobility. Besides Germany's efforts to promote electrification, the Federal Ministry for Economic Affairs and Energy(BMWi) has promoted hydrogen as an alternative fuel through the "Nationale Wasserstoffstrategie"(translated as National Hydrogen Strategy), released in 2020, positioning it as "key technology of the energy transition"(Bundesministerium für Wirtschaft und Energie 2020). The "Strategie Autonomes und Vernetztes Fahren"(translated as Strategy Automated and Connected Driving), released by the same Ministry in 2015, has three main goals: remaining the leading provider, becoming the leading market, and facilitating automated and connected driving(Bundesministerium für Verkehr und digitale Infrastruktur 2015). The strategy paper illustrates the strong identification of Germany not only as a leading automotive country but also as home to an automotive sector that defines its innovative potential and global standing. It recognizes the need to strike a balance between the legacy of leadership and the impetus for change: "The car was invented in Germany. We have revolutionized it again and again. And we are still at the forefront of innovation in the automotive sector worldwide. [...] With digitalization, we are now on the verge of a historic mobility revolution: Automated and connected driving. [...] Our country should further expand its position as a lead provider and become a lead market. Our goal is for key Mobility 4.0 technologies to be developed, researched, tested and produced in Germany"(Ibid., p. 3f). This also reveals elements that can hinder transformation: the strong incumbent role of car manufacturers, vested interests in the fossil fuel and car-centered economy, cities designed for automobiles, and the car as a cultural symbol of middle-class life and individual prosperity. In 2015, in Bavaria, where Munich is located, 197,000 people were employed by 1,100 companies in the automotive sector, generating sales of €102 billion. This emphasizes the critical importance of transforming this industry into the leaders of a new mobility sector(Invest in Bavaria, 2018).

To compensate for higher energy costs due to the Russian-Ukrainian war, the Federal Government set ticket prices for all public transport services in Germany at €9 during June–August 2022. The new co-creation and public engagement approach of the Technical University of Munich(TUM), MCube, and the TUM Think Tank allowed an immediate response to this large ad hoc intervention. In a very short period, we were able to find 1,000 participants to use an app we developed to track mobility behavior in real time; this allowed us to assess the changes resulting from the ticket intervention. The rapid feedback loop shortened planning cycles for sustainability significantly. As one study has shown, tickets have changed mobility patterns in Germany to the same extent as the COVID-19 pandemic.[2]

Because structures and frameworks at the national level may be more rigid, systemic changes can be tested more readily at the regional or local levels. Regions, cities, or even civic initiatives can make faster progress toward mobility transformation by experimenting with innovative solutions and alternative visions of mobility planning.

2 https://www.dlr.de/de/aktuelles/nachrichten/2022/03/20220825_wie-hat-das-9-euro-ticket-unsere-mobilitaet-veraendert (retreived: Nov 30th, 2023)

Mobility Transformation at the Regional Level: The Munich Region as an Example

Munich faces the same mobility challenges that many other metropolitan regions face. It is the most densely populated city in Germany and the fastest growing region nationwide, with more than 1.5 million inhabitants in the urban area and more than six million inhabitants in the metropolitan region. The housing shortage and the nationally outstanding nationally high rents are a significant problem. Munich also is Germany's "Stauhauptstadt"(translated as traffic jam capital; Rauch 2023) with regular congestion leading to residents wasting an average of 51 hours per year in traffic. Car traffic pollutes the air with particulate matter and greenhouse gas emissions. Other challenges include land use and urban sprawl, increasing commuting distances, the urban-rural divide, technological path dependencies, and rising social inequality. The COVID-19 pandemic relieved some of these problems and exacerbated others. The mandate to work from home changed commuting patterns and reduced emissions, while the desire to avoid social contact led to greater use of private cars and bicycles. Space was reconceptualized with a greater emphasis on proximity to neighborhoods, pop-up bike lanes, and the repurposing of parking lots for outside seating areas of restaurants, as seen in many other cities.

Mobility Policy at the Munich Level

Munich's Mobility Plan addresses three specific challenges: population growth; health and environmental protection; and digitalization and networking.[1] The overall strategy for transportation and mobility in Munich, "Mobilitätsstrategie 2035"(translated as Mobility Strategy 2035), was approved by the City Council in 2021. The strategy marks a shift from considering the mobility system's effectiveness only in terms of automotive mobility toward enabling mobility for everyone independent of the use of individual cars. Additionally, the strategy not only considers the level of mobility in the future but also emphasizes the quality of public spaces. In terms of specific Key Performance Indicators, the strategy "sets a concrete goal of ensuring that at least 80 percent of traffic in the Munich metropolitan area is covered by zero-emission motor vehicles, local public transport, and walking and cycling by 2025. Traffic is also to be climate-neutral by 2035." The plan lists 19 substrategies with their own targets: traffic safety, public transport, pedestrian traffic, cycling, shared mobility and mobility as a service,

1 https://stadt.muenchen.de/infos/mobilitaetsplan.html (retrieved: Nov 30th, 2023)

motorized private transport, multimodality, traffic control, management of public(road) space, mobility concepts in urban development and redevelopment, social justice, participation and inclusion, economic transport, climate and environmental protection, regional and commuter mobility, communication, digitalization, crisis stability and resilience, financing, research, and innovation. In the strategy development phase, Munich conducted a multistep participation process to include citizens and give them the opportunity to discuss the draft. This included public events and online discussion forums(ibid.).[2]

In 2019, Munich's City Council passed a resolution to make the old town car-free, with the outline of a more detailed roadmap expected in 2023. According to Weiss et al.(2023), instead of prescribing a designated traffic-free zone, the term "car-free" reflects a "vision to reduce motorized traffic and free-up public space for pedestrians, cyclists and public transport"(p. 9). The authors identify the constraints on these measures created by the Federal Road Traffic Regulations, which focus on avoiding danger rather than introducing more comprehensive, visionary urban development plans. Even in "traffic-calmed areas," "car traffic still has priority over pedestrian traffic"(ibid., p. 9f).

Another initiative that sought to prioritize alternative, active modes of transportation is the "Initiative Radentscheid"(translated as "initiative bike decision"). The initiative involved two citizen petitions demanding the expansion of the cycling infrastructure. In 2019, a petition with 160,000 signatures was presented to the city leadership, which confirmed that it would comply with the demands(Engels 2019). In this context, novel and superior bicycle lanes will be planned. The "Altstadt-Radlring"(Old Town Cycle Ring) will be established as a continuous and safe road around Munich's old town. One project team within the MCube Cluster has developed a comprehensive policy database that contains policies embracing different levels(from the city- to the European level) and areas(climate, sustainability, mobility and transport). The database will be continuously expanded and will function as a future resource for the MCube Cluster and beyond.

2 https://muenchenunterwegs.de/2035 (Retrieved: Nov 30th, 2023)

The Transformative Potential of Regions

Much of the potential for mobility innovation is currently insufficiently exploited. The implementation of novel ideas is fragmented and small-scale, as can be observed in many isolated living lab initiatives. However, transformation occurs at the metropolitan regional level. Urban areas are economic, scientific, and innovation centers, and metropolitan regions play a key role in shaping the future of mobility. By 2050, 70 percent of the world's population is expected to live in cities, representing two-thirds of global energy consumption and three-quarters of CO2 emissions(Kamal-Chaoui and Robert 2009). Therefore, the metropolitan regions in Germany and Europe are increasingly expected to provide a livable, economically stable, and ecologically sustainable future with technical and social innovations. The purpose of MCube is to harness the joint efforts toward mobility transformation solutions, making the metropolitan region of Munich a global model.

MCube:
The Munich Cluster for the Future of Mobility in Metropolitan Regions

4.1 Introducing MCube

"Mobility essentially determines where we live and work, how we live together, who can participate in society and how we survive ecological transformations"(MCube 2020, p. 1). Mobility and the mobility system play a key role in Germany, shaping regional economic strength, innovation, and quality of life. This premise forms the foundation of a holistic approach to mobility transformation in the metropolitan region of Munich. While transformation is animated by a vision, conflicts and challenges arise from the complex intersection of mobility with other sectors, businesses, stakeholders, and technologies. Mobility plays an important role in addressing the global challenges of climate change and sustainability. Indeed, several of the UN development goals relate to mobility such as "Sustainable Cities and Human Settlements," "Combating Climate Change," and "Healthy Lives for All."[1] Additionally, the role of mobility in Germany's leadership and competitiveness is unquestionable. New innovative start-ups from North America and Asia, where the financially strongest investors are also located, enter the market, as do companies with business models based on user data.

The Munich Cluster for the Future of Mobility in Metropolitan Regions

In 2019, the German Federal Ministry for Education and Research launched its "Zukunftscluster-Initiative Clusters4Future"(translated as the Future Cluster Initiative). The goal of this new funding structure is to support future clusters that will serve "as the next generation of regional innovation networks."[2] The clusters "are more dynamic and willing to take risks than ever before. They stand for pioneering spirit, creativity and collaborative strength. Future clusters embody an open culture of innovation and risk-taking, in which relevant partners in burgeoning fields of technology and knowledge form new networks. This results in cross-industry, cross-topic, cross-technology and cross-disciplinary collaborations that provide new impetus and overcome boundaries." MCube is one of these new regional innovation networks. In 2021, the MCube proposal, led by TUM, was selected as one of seven national clusters; it was the only cluster focusing specifically on mobility innovation in urban spaces and extending to metropolitan regions. The first round

1 https://sdgs.un.org/goals (retrieved: Nov 30th, 2023)

2 https://www.bmbf.de/bmbf/de/forschung/zukunftsstrategie/zukunftscluster-initiative-clusters4future/zukunftscluster-initiative-clusters4future_node.html (retrieved: Nov 30th, 2023)

of 14 funded projects started in 2021 and will run for three years. The projects can potentially be extended with two follow-up rounds of three years each, which will be supported from a €45 million funding pool.

MCube emerged in response to the unique confluence of factors that made Munich the ideal epicenter for pioneering sustainable and transformative mobility innovations. MCube's genesis is closely tied to Munich's exceptional resources and position as a frontrunner in the global mobility sector. Munich, often hailed as the academic powerhouse of Europe, is home to some of the world's leading universities, research institutions, and DAX corporations. Industry giants, such as Google, Apple, Facebook, and Microsoft, have recognized the city's potential and established a significant presence. Moreover, Munich boasts the UnternehmerTUM, Europe's premier start-up and entrepreneurship center, which fosters a vibrant ecosystem for innovation and entrepreneurship. Collectively, these factors form a robust foundation for ambitious initiatives. Yet, MCube exceeds the apparent allure of Munich: It was born of the necessity of harnessing the city's unparalleled strengths in the mobility sector and channeling them into a collaborative forward-thinking cluster. This is because MCube leverages Munich's academic excellence, research capabilities, corporate innovation, and startup dynamism to create a transformative force in mobility.

The decision to establish MCube in Munich aligns with the region's commitment to sustainable development and environmental responsibility. Munich's leadership in green initiatives and its dedication to addressing environmental concerns made it a natural fit for MCube's mission to improve air quality through innovative mobility solutions. Furthermore, Munich's strategic location within Europe and its accessibility to major metropolitan regions provide practical advantages for MCube. This allows the cluster to serve as a hub for developing scalable mobility solutions that can be replicated in similar metropolitan regions both in Germany and across the world.

Actor and Stakeholder Network

MCube encompasses a unique network of actors from science, business, government, and society in the Munich region working together to develop sustainable solutions for mobility in metropolitan regions through mission-driven innovation approaches. The consortium brings together nationally and internationally leading research institutions and corporations in areas such as autonomous driving, electromobility, urban development, social innovation, and mobility services; the collaboration also includes a diverse range of innovative small and medium-size enterprises(SMEs) with vibrant entrepreneurial spirit, addressing one of the crucial societal challenges of the future. As an "Entrepreneurial University" at the heart of the innovation ecosystem, TUM provides an ideal foundation for an open innovation culture oriented toward the common good; it explicitly promotes technology transfer and the establishment of new companies. MCube's hallmark is its focus on balance in complex transformation processes between the technical and social aspects of innovation and between scientific excellence and application orientation. The relevant technical excellence in MCube, including mechanical and vehicle engineering, digitization, autonomous systems, charging technology, logistics, and infrastructure development, is complemented by a broad spectrum of expertise in urban planning and business-related aspects of mobility innovation, as well as an interdisciplinary collaboration of qualitative and quantitative social sciences. Furthermore, MCube intensifies the deep integration and direct cooperation between science and business partners(industry, SMEs, start-ups) and societal actors(cities and municipalities, public associations, civil society), a crucial criterion in selecting innovation projects.

4.2 MCube’s Mission

MCube’s goal is to align mobility innovations consistently with societal challenges. The mission-driven approach is gaining traction in innovation research and European technology policy. In this approach, "missions," serving as overarching societal goals for innovation, are defined at the regional or national level based on concrete challenges. These missions enable evaluation of innovation success. Missions function as organizational principles for regional innovation activities and competencies among various stakeholders, bridging the gap between global challenges and local structures and needs. As an evolution of traditional cluster approaches, the public sector and civil society play a pivotal role in complementing regional innovation activities that focus on the common good rather than solely relying on scientific and technical expertise or private sector interests. The transformative ambition of missions requires a holistic and open innovation process that engages research and development with the active participation of local business, society, and municipal actors. MCube's mobility mission spans three themes: improving the quality of time, space, and air for citizens in the Munich metropolitan region.

Quality of Time. In addition to the traditional criteria, this mission focuses on accessibility, which is the ability to reach all everyday destinations comfortably, reliably, and punctually with limited time and resource expenditures(both internally and externally). Future mobility should enable travelers to use routes more easily, efficiently, flexibly, and sustainably through connected intermodal mobility offerings and digital applications. This also affects site development, with key objectives within the region and centers being reachable within 30 minutes, and neighborhood routes targeted to be within 10 to 15 minutes by foot or bike. Additionally, transportation quality, including various levels of service, plays a central role in differentiating between different modes of transport. Recently, experience quality has become an increasingly important criterion in mobility, given that travel trades against other objectives such as work, communication, reading, relaxation, and sports.

Quality of Space. This mission reflects the impact of mobility innovation on public urban spaces. In future metropolitan regions, there should be new recreational and movement spaces accessible to the entire population. Streets should prioritize pedestrian and bicycle traffic, as well as public transportation, resulting in overall mobility benefits and a livable space for the population. Projects related to shared, autonomous, or on-demand mobility and logistics go hand-in-hand with questions about urban design, quality of stay, and social justice. An essential criterion here is usage diversity, involving space-saving and flexible development of transportation and settlement areas, while considering open space protection, green and blue infrastructure, and dynamic and flexible infrastructure use. Safety is equally important, measured in terms of the risk of injury or traffic fatalities("Vision Zero") and safety criteria for digital infrastructure(data security, individual data usage rights, and social acceptance). Finally, quality of stay is highly relevant. In this context, mobility is seen in connection with the possibility of staying in streets, cities, natural areas, and open spaces, which, in turn, affect economic strength, social justice, integration, and the development of new experiential spaces.

Quality of Air. This mission addresses the environmental impacts resulting from transportation and, thus, global climate protection. All innovation projects in MCube work toward not only reducing local air pollutants, such as nitrogen dioxide(NO2) and particulate matter(PM), but also contributing to global climate protection by reducing CO2 emissions. Specifically, the cluster aligns with the national goal of the German government's climate protection program to reduce greenhouse gas emissions in the transportation sector by at least 40 percent by 2030. For MCube, this means pursuing climate-neutral mobility solutions and incorporating previously externalized costs in mobility offerings, both by the city and by companies. At the individual level, air quality also concerns health protection, which has become more important than ever for many travelers, given the attention to infection risks triggered by the COVID-19 pandemic. Beyond COVID-19, this relates to issues such as spores, bacteria, allergies, and hygiene in the context of mobility.

4.3 MCube's Guiding Principle for Mobility Innovation: "Miteinander Möglich Machen"

Mobility transformations have many potential complications, particularly if they are through technological, political, and social innovation. The first autonomous cars operated by Uber and Waymo had accidents. Singapore-based Obike provided bikes as a service but retreated from the German market after Munich had been "flooded" with them (Nöhbauer 2019); the bikes were criticized for their poor quality and subject to vandalism, ending up in trees and rivers or hung on road signs(ibid.). Innovators pursue acceptance because, despite their best efforts, society often rejects novel products or services as impractical or risky. Other technologies might only show unintended consequences several decades later after having produced significant lock-in effects that make it extremely difficult to change course(Collingridge 1980).

Despite popular theories in fields such as business and economics, innovation is seldom a unilinear process that moves from basic to applied research(Pfotenhauer and Juhl 2017), with its outputs unanimously publicly cherished. Research in Science and Technology Studies(STS) has shown, for instance, that the way in which technological designs turn out is by no means self-evident and unquestionable. A study by Pinch and Bijker (1984) documents how, at a certain point in time, different conceptualizations of how a bicycle could look existed in parallel. The bicycle, as we know it today, was then able to take precedence, as different groups with stakes in their design were able to mobilize the artifact to solve specific social problems, making one alternative more desirable than the other. This study highlights how technological developments are shaped by the social contexts in which they emerge. Another seminal paper by Urry(2004) contends that the automobile, another technological artifact, should be understood as a "system" of automobility rather than just as a manufactured object. Its meanings include its role as a dominant culture, environmental resource use, and a complex set of technical and social interlinkages. Urry(2004) states that "automobility can be conceptualized as a self-organizing autopoietic, nonlinear system that spreads world-wide, and includes cars, car-drivers, roads, petroleum supplies and many novel objects, technologies and signs. The system generates the preconditions for its own self-expansion"(p. 27).

A social science perspective on the mobility transition highlights the local political and social context in which innovation takes place. It also directs attention to the development processes of innovation and helps us understand why certain products and services might simply not "work" in society as envisioned during the R&D process. As stated in MCube's strategy paper, "At the same time, mobility innovations create societal tensions and raise complex social, legal, and ethical issues - observable in controversies around Uber, automated vehicles, and data privacy, but also in the redistribution of public space - that can only be constructively addressed through better participatory, inclusive, and responsibility-oriented innovation processes"(MCube 2020, p. 2). We put this part of the strategy into practice through the guiding principle "Miteinander Möglich

Machen," which can be translated as "together we can make things possible." This leitmotif is rooted in MCube's local and regional context of actors and stakeholders and manifests in the interplay of MCube's three specific missions in the Munich metropolitan region. At the same time, it represents a commitment to co-creation and participatory processes. MCube's commitment to these principles, formalized in its mission statement, inheres in all activities and subprojects. It guides the structure of MCube from the level of strategic governance to the way in which the stakeholder constellation in projects is designed and the public is addressed. In the following section, we provide an in-depth case study of MCube and its contribution to mobility transformation, documenting the implementation of the guiding principle and how we hope to deepen this endeavor in the future.

"Together" (Miteinander)

The first pillar of MCube's guiding principle is "Miteinander," which means "together." This domain addresses interdisciplinary research, transdisciplinarity with new fields, integration of different sectors (science, business, and society), strong regional networking, early citizen participation, and co-creation. One important idea is the concept of responsible research and innovation(RRI). Generally, responsible innovation frameworks seek to transform how innovation processes are governed by engaging those who conduct research with those who must live with such innovation. This refers to both the inter- and transdisciplinary sets of stakeholders and the public. A widely used definition was provided by Stilgoe et al. (2013): 'Responsible innovation means taking care of the future through collective stewardship of science and innovation in the present'(p.1570). In summary, despite a variety of definitions, different RRI concepts share as a general orientation a shift in innovation governance toward process orientation rather than just providing a specific solution(Stahl et al. 2021). This extends "beyond a purely technical understanding of innovation"(Burget, Bardone, and Pedaste 2017, p. 4) and indicates a move from risk governance to innovation governance(Macnaghten et al. 2014). In the EU context, its most central principle is "science with and for society"; research and innovation should be oriented toward societal values and conducted democratically, emphasizing public engagement and participation. With the rising popularity of this concept, it has been applied in areas such as neurotechnology(Pfotenhauer et al. 2021), smart agriculture(Fleming et al. 2021), and autonomous driving(Lukovics et al. 2020). However, to date, there has been no comprehensive adoption of responsible innovation in the area of mobility innovation. The purpose of the MCube project, "Responsible Mobility Innovation, and Governance"(ReMGo), was to address this gap.

"We can make" (Machen)

The second pillar of MCube's guiding principle is "Machen," which means "we can make." This dimension emphasizes a strong implementation focus, transferring science to practice and business, encouraging entrepreneurial actions, and ensuring the scalability of solutions beyond the region in national and international competition. In this context, so-called "living labs" – designated experimental spaces where technologies and their transformative effects are tested and iteratively improved on a small scale under real conditions – offer the opportunity to include diverse interests in the innovation process and co-create technology. Advanced living lab strategies view society not as a passive testing ground but as an active partner in development, a source of feedback, and a benchmark for social acceptance(Engels, Wentland, and Pfotenhauer 2019). In MCube, several projects use the living lab approach, which includes a platform for continual exchange among stakeholders who work with living labs to develop a more standardized protocol within the Munich region.

"Possible" (Möglich)

The third pillar of MCube's guiding principle is "Möglich," which means "possible." This signifies the courage to explore experimental and innovative solutions and to facilitate such an approach. An important factor is the development of new technologies within an open innovation culture supported by open-source and open-data approaches. MCube's data hub, for instance, serves as a platform for the entire cluster consortium, displaying the availability of different datasets and offering access depending on the respective governance framework. MCube also emphasizes connecting various stakeholders through joint exchanges both with the public and within the consortium, such as regular events with project updates or public speaker series. Another crucial aspect is the governance structure of the MCube cluster, including mechanisms that allow for reflexivity and responsiveness(Stilgoe et al. 2013), supported by cluster-internal evaluations. Generally, MCube follows the vision of enhancing regional quality of life and creating a sustainable future for society.

4.4 MCube in Practice: Selected Innovation Projects for "Miteinander Möglich Machen"

AQT - Car-Reduced Cities Replacing Car-Centric Cities: In the project "Car-Reduced Neighborhoods for a Livable City"(AQT), the project team is developing and testing design, traffic, and regulatory concepts using two neighborhoods in Munich. The objectives are to increase the acceptance and use of multimodal transportation options, significantly reduce individual car ownership and use, and enhance urban space. New integrated approaches to urban and traffic planning are important for sustainable and climate-adapted urban development in the face of ongoing urbanization. In a large five-month living lab, over 80 parking spaces in an existing neighborhood in Munich were transformed. The temporary transformation of street sections into green oases and the creation of new open spaces through the repurposing of parking areas are innovative approaches for making urban spaces more livable and promoting active mobility. The AQT project team in Munich demonstrated that such projects could be successful even in densely populated urban areas. Interestingly, similar projects have failed in other German cities, such as Berlin, Hamburg, and Stuttgart. This can be attributed to various factors:

- *Local Support and Acceptance:*

The success of such projects often depends on the support and acceptance of the local community. If citizens are not engaged in the process of change, or if their concerns are not adequately considered, it can lead to resistance and failure.

- *Political Support:*

Political leadership plays a crucial role in implementing urban planning.

If political decision makers do not support such projects or fail to establish clear policy guidelines for implementing changes, they can hinder their execution.

- *Funding and Resources:*

Adequate funding and resources are critical for such projects. The lack of funds and resources to carry out the transformation and provide the necessary infrastructure can pose challenges.

- *Communication and Public Relations:*

Effective public relations is paramount. If the benefits and objectives of a project are not clearly communicated, or if misunderstandings exist, it can lead to rejection.

MCube has evidently succeeded in addressing these challenges and involving citizens in the process of change. The experiences of and responses from MCube can serve as best practices for other cities seeking to undertake similar urban planning changes and mobility projects. Through a participatory approach and close collaboration with the community, such projects can accelerate the transition to sustainable transportation and the transformation of urban spaces across Germany.

Wiesn Shuttle - Autonomous Driving as a Building Block for Reducing and Improving Traffic. Autonomous driving has the potential to reduce passenger and freight traffic and improve the journey experience. Autonomous shuttles, for instance, could facilitate more flexible, comfortable, efficient, and high-performance transportation systems. Autonomous systems also have the potential to increase road safety and enhance mobility for patients, seniors, and children. As key technologies, autonomous driving and connectivity have the potential to make new mobility solutions, such as car sharing and mobility on demand, economically scalable, thus transitioning them from primarily single-study concepts requiring substantial funding to practical applications. While the technical potential has been repeatedly demonstrated, further efforts in research, development, and societal discourse are needed to facilitate the widespread use of this technology, as society lacks the knowledge, acceptance, and necessary legal framework for dealing with autonomous vehicles. Driving in unstructured environments such as crowds and complex urban traffic situations presents a practical obstacle to the use of this technology. MCube identifies and addresses these issues to implement practical solutions.

The aim of the project Wiesn Shuttle is to demonstrate how autonomous driving may work in a highly complex environment. The city of Munich collaborates closely with the engineering faculty of TUM, traffic planners, and startups to operate an autonomous shuttle during the Oktoberfest, the world's largest folk festival. This is the first time an automated mobility solution has been implemented under such extreme conditions (unstructured traffic, day and night driving), targeting a large number of different road users from all socioeconomic backgrounds. Thus, MCube has established a highly impactful real-world laboratory, providing robust algorithms and software, setting a basis for the commercialization of new mobility solutions in an urban context, and developing concepts for upscaling and planning of autonomous on-demand shuttles to replace motorized individual traffic.

TrEX - Establishment of a "Living-Labs Competence Center." The "Transformative Mobility Experiments"(TrEx) project is already gaining experience from MCube's living labs, condensing this knowledge systematically, and developing guidelines for responsible and safe experimentation in urban spaces. TUM, the Mobility Department of the City of Munich(LHM), and TÜV SÜD are jointly designing processes and validation standards to be used in Munich and beyond in various types of living labs. Simultaneously, a competence network is being established, allowing both the city and companies to access results, insights, and contacts when planning future living labs. Furthermore, the living labs resulting from TrEx will be integrated into the city's mobility strategy and politically supported. Project partners such as TÜV SÜD and SAP are examining their innovation practices based on initial living lab models with the intent of using their results to create new products and services. The project brings together different stakeholders from the private and public sectors. It opens up new possibilities through knowledge exchange and support with regard to questions of responsible experimentation; it also supports the implementation and hands-on nature of MCube through the assistance of living labs.

ComfficientShare - Charging Infrastructure and Neighborhood-Owned E-Car Sharing Replacing Individual Traffic. The project goal is based on the premise that ten neighbors in a typical urban building own an average of 13 cars, which are parked in an underground garage and remain unused for 95% of the week. MCube is addressing the lack of electrical infrastructure for cars in existing buildings to create incentives for tenants to change the status quo. MCube has been actively implementing this in the ComfficientShare living lab since 2023. In the closed-sharing system, we started with seven households using only five vehicles that we provided to test how the vehicle inventory in urban residential areas and investment costs for charging infrastructure can be reduced. This can lead to business models for charging infrastructure and car-sharing operators.

In ComfficientShare, a diverse network of actors from academia, automobile manufacturers, real estate providers, e-charging startups, and civil society comes together to test a radically reimagined sharing approach in an immersive real-world laboratory.

SASIM - A Full-Cost Perspective on Urban Transport to Significantly Change Individual Mobility Behavior. The "Smart Advisor for Sustainable Integrated Mobility"(SASIM) tool functions as an online full-cost calculator that provides sustainability-assessed mobility options for individual route inquiries. The sustainability of transport options is assessed using an index("Mobi-Score"). This score aggregates the externalities caused by the mode of transportation to provide a comprehensive assessment of sustainability. In addition, innovative approaches will be developed to promote sustainable mobility behavior through cost transparency for decision-makers, awareness building, and planning and control elements. Consequently, scenarios for a comprehensive and dynamic pricing system based on the full cost of different mobility options are created. Price incentives, which can be embedded in a future mobility-as-a-service(MaaS) system, influence mobility behavior across various modes of transportation. Further strategic application perspectives for SASIM will be elaborated, thus ensuring the usefulness of the project outcomes for planning practice and policy.

The project epitomizes the MCube guiding principles by uniting researchers from various fields, including marketing, urban planning, and transport engineering with partners from industry and the public sector(public transport operations, vehicle manufacturing, and different planning levels). SASIM not only provides an overview of the full costs of different mobility forms but also paves the way for innovative applications to make mobility behavior more sustainable. Project results can be easily transferred into practice through customer communication or political decision-making processes. In the long-term, MaaS concepts, which link sustainability goals with pricing mechanisms, could be implemented in Munich and other metropolitan regions.

Table 1 illustrates the extent to which each of the presented innovation projects contributes to MCube's guiding principle "Miteinander Möglich Machen." A larger circle indicates a larger contribution to the corresponding dimension. For example, the projects AQT, Wiesn Shuttle, and ComfficientShare all feature a highly visible living lab, thus providing a large contribution to the degree of implementation represented by "We can make."

Table 1 *Contributions of the selected innovation projects to the MCube guiding principles.*

Guiding Principle for Mobility Innovation	**Together** degree of stakeholder diversity	**We can make** degree of implementation	**Possible** potential of innovation
AQT	◉	◉	•
Wiesn Shuttle	•	◉	◉
TrEx	◉	•	•
ComfficientShare	◉	◉	◉
SASIM	◉	•	◉

Additionally, MCube is working to establish a citizens' forum enabling active participation and engagement of the public through various formats. Selected citizens are being invited to become involved in MCube by defining and specifying mobility challenges. Their specific knowledge and perspectives provide a basis for the continued development of the MCube strategy and its R&D projects. The application of such a citizen forum is being tested and evaluated for the first time in a Munich mobility cluster. The organizational process as well as the content-related output of this citizens' forum can set an example both regionally and in the national context.

Conclusion: Lessons and Recommendations

How can regions shape the future of mobility? How can regional innovation clusters function as drivers of the mobility transition? How can innovation be responsibly conducted? What are the most important national trends and strategies in Germany in which mobility innovation is embedded? Our contributions start a conversation on these questions for potential interregional and international comparison and exchange of experiences and best practices.

Based on a review of current mobility policies and strategies at the EU level and in Germany, this chapter takes a closer look at the regional scale innovation. MCube is a real-world example of the challenges and potential of mobility innovation. Our study shows how regional strategies for mobility transformation can bridge the gap between the EU and national policies and local strategies, between global trends and situated solutions, between visions and the capacity to put ideas into practice, and between various unconcerted efforts to change the world for the better. With MCube, we put mobility innovation into practice through the guiding principle "together we make things possible," which emphasizes collaboration, co-creation, participation, and responsible innovation.

The famous quote "It takes a village to raise a child" means you need an entire community of nurturing families, supportive neighborhoods, effective schools, sports facilities, libraries, and more to raise a self-determined, responsible, and curious person. The same applies to the complex field of mobility transition. Munich brings that community together in MCube and shows how to co-create the future of mobility. The unique amalgamation of cutting-edge research, leading industry, an active civil society, impact-driven city administration, and vibrant start-up ecosystems offers immense innovation potential. However, Munich is not the only place that brings together this type of ecosystem. Many innovation hubs worldwide share similar characteristics. What often seems to be lacking is the close collaboration of diverse stakeholders working towards a common goal or genuine co-creation on an equal footing. This requires the willingness to allocate resources, understand other stakeholders, and collaborate with them. The strategic shift requires recognition that innovation is not solely a technical matter; instead, it must be fundamentally aligned with societal considerations. MCube exemplifies this transdisciplinary approach. The MCube cluster allows Munich and its region to reimagine mobility innovation. This prompts us to think not just about the technologies we possess but also about how to create them in a way that is aligned with society's values. More importantly, it is about the problems we aim to solve and the people for whom the solutions are designed. To enable and accelerate the mobility transition, cities and regions need to integrate these aspects seamlessly to create a truly intelligent, inclusive, green, and livable city.

ACKNOWLEDGEMENTS:

We are grateful to the Konrad-Adenauer-Stiftung e.V. for their generosity in hosting a joint workshop for the authors of this edited volume in Sejon, South Korea, as well as to all participants of the workshop for their lively discussions and valuable feedback on our contributions. We would also like to thank our colleagues at the Technical University of Munich, Alina Weiss and Markus Kober, for their support in creating this work.

KONRAD ADENAUER STIFTUNG

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Technological Aspects of Mobility Transformation in Germany

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Introduction

The German government has set a target of reducing greenhouse gas (GHG) emissions in the transport sector by 48% by 2030, compared with 1990.[1] This primarily requires a reduction in traffic or a shift towards eco-friendly transport modes and a technological transformation of drive systems. Both requirements are known in Germany as "*Verkehrswende*," which can be translated as "transport transition." The distinction between reduction and modal shift is usually referred to as the "mobility transition"(*Mobilitätswende*), whereas the technological change in driving is termed the "propulsion transition"(*Antriebswende*).[2] These definitions are especially important in international contexts because they usually guide public debate in Germany.[3] In comparison, the term "mobility transformation" is more commonly used in international literature(and sometimes even German literature) as a synonym for the German term "transport transition," which includes traffic reduction, modal shift, and technical transition. This chapter discusses this all-encompassing concept and, therefore, uses the term "Mobility Transformation." The chapter focuses on technical innovations and therefore relates predominantly to the "propulsion transition." Nevertheless, the reduction and eco-friendly modal shift of traffic is an important aspect of achieving climate protection goals and is also examined. A mere energy transition or change in transport technology will not be sufficient to achieve climate protection goals.[4 5] This chapter also discusses technologies that can change mobility behavior, which may lead to a modal shift.

Before examining the technological aspects of mobility transformation in Germany, two relevant aspects need to be considered. The first is the current discussion of openness to technology, and the second is the general role and history of the automotive industry in Germany.

In the context of transport sector transformation, technological openness is defined as open competition between alternative drive systems and energy sources. The extent to which alternative technology is promoted depends on the level of knowledge about the economic costs and ecological and social benefits of the various drive technologies and energy sources. The levels of knowledge about developments in the individual modes of transport vary, with battery electric vehicles being associated with the greatest benefits, particularly in the passenger car segment. Accordingly, government interventions could focus on promoting battery-powered electric passenger cars.[6] The promotion of some new technologies for mobility transformation is currently being

1 Germany's Climate Action Law (https://www.cleanenergywire.org/factsheets/germanys-climate-action-law-begins-take-shape)

2 https://www.vcd.org/artikel/verkehrswende-definition

3 Katharina Manderscheid (2020, Achim Brunnengräber, Tobias Haas(2020): "Antriebs-, Verkehrs- oder Mobilitätswende? Zur Elektrifizierung des Automobilitätsdispositivs"(PDF), Baustelle Elektromobilität – Sozialwissenschaftliche Perspektiven auf die Transformation der(Auto-)Mobilität(in German), Bielefeld: transcript, pp. 37-67, ISBN 978-3-8376-5165-2, retrieved 11 August 2020.

4 https://www.agora-verkehrswende.de/12-thesen/die-verkehrswende-gelingt-mit-der-mobilitaetswende-und-der-energiewende-im-verkehr/

5 https://www.dlr.de/de/aktuelles/ nachrichten/2021/04/20211209_szenario-report-des-ariadne-projekts

6 https://www.forschungsinformationssystem.de/servlet/is/572342/

discussed in the political system.[7] The discussion mainly focuses on e-fuels[8] and hydrogen as alternative drive systems. The *Fraunhofer-Institut für System- und Innovationsforschung*[9] and Agora *Verkehrswende*[10] concluded that e-fuels were not useful for passenger and goods transport. The Federal Environment Agency(*Umweltbundesamt*) considers the direct use of electricity to be the preferred option wherever electrification is technically possible and sensible. In aviation and maritime transport, where electrification is unlikely to be an option compared with road and rail transport, synthetic fuels based on power-to-liquid or power-to-gas could be more economically advantageous than green hydrogen.[11] There is disagreement as to when one or more technologies should be chosen and others excluded,[12] because of the need for fast reduction of emissions in transport for climate protection.

The second contextual topic concerns the role of the automotive industry and the status of automobiles in society. To transition towards climate neutrality by transforming engine technology(e.g., from combustive to electric), the automotive industry requires a high level of financial support in the form of subsidies. This applies in Germany and other European Union Member States. The Alliance of Automobile Regions(ARA), which represents the interests of 34 EU members, declared that the EU Commission should consider extending funding allocations. "Otherwise, there is a risk that the industry would 'fall behind' internationally."[13] The consulting company McKinsey also found that the European automotive industry needs a new master plan to remain competitive.[14]

However, the industry itself and the general role of cars in society significantly influence the mobility transformation in Germany. In the years after World War II, automobiles experienced a success story, which not only led to a massive expansion of road infrastructure but also shaped the way automobiles were viewed in society. In the post-war period, automobiles symbolized economic growth.[15] The car was and is sometimes still seen as a "narrative of a happy and successful life," such that achieving "an aspired modern lifestyle" has become an important indicator of the economic growth model.[16] The car was viewed less as a technical device and more as part of the philosophy of a self-determined and free life,[17] giving it a highly symbolic character. This is still somewhat true today and must be considered in the context of the mobility transformation in Germany.

7 Note: currently discussed in 2023, e.g.: „"Wissing startet internationalen E-Fuels Dialog", 04.09.2023. https://bmdv.bund.de/SharedDocs/DE/Pressemitteilungen/2023/087-wissing-startet-internationalen-e-fuels-dialog.html

8 "The "E" in e-fuels stands for electric current. It is not a legally clearly defined term. In general use, however, this refers to liquid, synthetic fuels that are produced from water and CO2 using electricity." - https://www.bmuv.de/faq/was-sind-e-fuels

9 https://www.isi.fraunhofer.de/de/presse/2023/presseinfo-05-efuels-nicht-sinnvoll-fuer-pkw-und-lkw.html

10 https://www.agora-verkehrswende.de/veroeffentlichungen/e-fuels-zwischen-wunsch-und-wirklichkeit/

11 https://www.umweltbundesamt.de/presse/pressemitteilungen/elektromobilitaet-volkswirtschaftlich-klar-im

12 https://www.forschungsinformationssystem.de/servlet/is/572342/

13 https://background.tagesspiegel.de/mobilitaet/eu-automobilregionen-fordern-bessere-finanzielle-unterstuetzung

14 https://background.tagesspiegel.de/mobilitaet/mckinsey-masterplan-europas-autoindustrie-braucht-strategiewechsel

15 Buchmann, Lisa(2019): „If you plan for people and places..." – Perspektiven autoarmer Stadtquartiere. Berlin. 2019, p. 2

16 Canzler, Weert und Knie, Andreas(2019):

In summary, the automotive industry has a significant impact on the economic, political, and social discussions around mobility transformation,[18] which is why the topic is being widely discussed. In the context of the mobility transition in Germany, as defined above, a variety of technologies must be considered because there are different approaches, opinions, and innovations for tackling the mobility transition. Owing to the large number of technologies, this report cannot cover all of them. Therefore, the focus will be on the key trends in electromobility, autonomous driving, and smart mobility. In the context of these trends, the selected relevant technologies, particularly for passenger transportation, are explained in detail below.

Autodämmerung – Experimentierräume für die Verkehrswende. Strategiepapier. Berlin. April 2019, p.9.

17 Canzler, Weert und Knie, Andreas(2019): Autodämmerung – Experimentierräume für die Verkehrswende. Strategiepapier. Berlin. April 2019, p.11

18 Canzler, Weert(2016): Automobil und moderne Gesellschaft – Beiträge zur sozialwissenschaftlichen Mobilitätsforschung. In: Mobilität und Gesellschaft. Band 6. Hrsg. Canzler, Weert; Rammler, Stephan; Schwedes, Oliver. LIT Verlag Dr. W. Hopf. Berlin. 2016

Electromobility

Electromobility is one of the most important technologies for transforming transport in Germany. As described in the introduction, electromobility offers considerable advantages over synthetic biofuels, hydrogen, and fossil fuels in terms of efficiency and reduced transport emissions. Therefore, this chapter focuses on the state-of-the-art electromobility technologies in Germany for passenger and freight transport.

Germany's climate goals require the electrification of road transport, more extensive use of renewable energy, and a reduction in traffic in general. A prerequisite for this is further expansion of the charging infrastructure.

With the regulatory framework and technical course set in the "Charging Infrastructure Master Plan II,"[1] the ramp-up of electromobility will make a key contribution to the transformation of the transport and energy sectors and, therefore, to climate protection. Beyond the master plan for charging infrastructure, there are various targets at the local level in Germany(like the "Berlin Model"[2] or the "Urban development plan for mobility and transport" of Berlin [StEP Move][3]) as well as at the EU level(like RED III[4]) (see also Chapter 4).

1 https://nationale-leitstelle.de/wp-content/uploads/2023/04/20230419_Masterplan-Ladeinf rastruktur-II-der-Bundesregierung_barrierefrei.pdf

2 "The overall approach of the 'Berlin model' towards electromobility intended to give easy and non-discriminatory access to charging infrastructure on public streets to every EV driver."(https://www.userchi.eu/wp-content/uploads/2020/10/Berlin-2.pdf); http://www.be-emobil.de/en/background)

3 https://www.berlin.de/sen/uvk/mobilitaet-und-verkehr/verkehrspolitik/stadtentwicklungsplan-mobilitaet-und-verkehr/

4 https://www.bmwk.de/Redaktion/DE/Pressemitteilungen/2023/06/20230616-neue-eu-richtlinie-fuer-erneuerbare-energien-angenommen.html

E-Vehicles

To understand the differences between the available technologies for the mobility transition in Germany in the Electric Vehicle(EV) sector, it is necessary to understand the differences in market share and impacts on climate protection targets. EVs can be classified based on the engine technology they use into four types: Battery Electric Vehicles(BEVs), Plug-in Hybrid Electric Vehicles(PHEVs), Hybrid Electric Vehicles(HEVs), and Fuel Cell Electric Vehicles(FCEVs).

1 Every third electric car in Europe start its journey in Germany(numbers from 2022). https://www.solarserver.de/2021/12/16/jedes-dritte-elektroauto-in-europa-faehrt-in-deutschland-los/

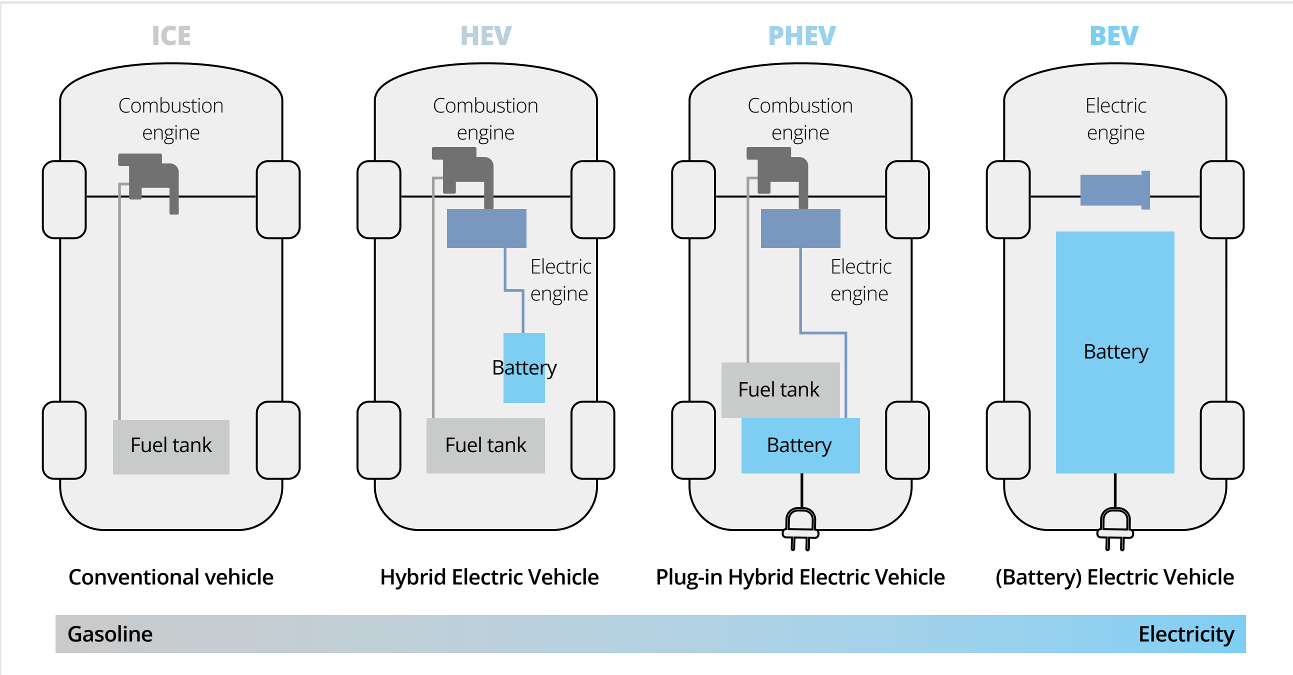

Figure 1. Overview of the different technologies in comparison to an internal combustion engine(ICE).

Source: https://greenpowersystems.com/clean-transportation/commercial-evse/ice2bev/

Overall, there has been a significant increase in the use of e-vehicles for passenger transport in Europe, particularly in Germany.[1] In 2020, Europe had the second-highest EV stock in the world, with 1.4 million PHEVs and 1.8 million BEVs.[2] The rapidly growing sales share of new electric cars in Europe(from 0.5% in 2013 to 10.5% in 2020) indicates an increasing number of EV users.[3] This trend has been more pronounced in Germany than in Europe as a whole, especially since 2020. In 2013, 7,436 electric car registrations(PHEV+EV) were recorded,[4] representing less than one percent of the total new registrations.[5] Since 2020, the annual number of new registrations for electric cars has increased(2020: 394,632; 2021: 661,410; 2022: 832,652).[6] In 2022, nearly one-third of registered cars were electric.[7] This period has been called an "electro-vehicle boom," with the total market share in Germany growing from 3% in 2019 to 14% in 2020 to 26% in 2021 and 2022.[8] The market leaders in Germany are

2 International Energy Agency (IEA) (2021), Global EV Outlook 2021, online available at: https://www.iea.org/reports/global-ev-outlook-2021(last consulted: 19.09.2023).

3 European Alternative Fuels Observatory(EAFO) (2022), Vehicles and fleets – AF(Alternative Fuels) Market share of new registrations, online available at: https://alternative-fuels-observatory.ec.europa.eu/transport-mode/road/european-union-eu27/vehicles-and-fleet (last consulted 19.09.2023).

Volkswagen, Tesla, and Renault. The Renault Zoe has the highest number of registrations.[9]

This can be primarily attributed to two policy instruments: CO2 fleet limits and purchase subsidies,[10] as revealed when registrations in January 2023 declined after changes in purchase subsidies in December 2022.[11] As of January 1, 2023, the revised funding criteria for environmental bonuses[12] exclusively support BEVs and FCEVs. PHEVs are no longer eligible because of their low real electric share of driving.[13] Until this change, a large proportion of the registered electric cars in Germany were PHEVs.[14] This may account for the decrease in registration figures of electric cars in total by the beginning of 2023.However, current sales figures fall short of the political target of putting 15 million BEVs on the roads by 2030.[15] This goal would require nearly 5,000 registrations of BEVs per day.[16]

The variations between electric vehicles are determined by their efficiencies, which are measured as percentages of the energy consumed by the vehicle. BEVs rank the highest, with an efficiency of 64%, followed by FCEVs at 27%, compared to 20% for petrol engines.[17] Therefore, the BEV consumes the least energy as a result of the energy saved during the transfer from the energy source to the car(well-to-wheel assessment[18] in comparison to FCEV and gasoline engines[19]). Therefore, FCEVs have been extensively discussed in Germany. FCEVs use compressed hydrogen gas as fuel to generate electric power via a highly efficient energy converter called a fuel cell. Fuel cells directly transform hydrogen into electricity to power an electric engine.[20] While hydrogen is seen as an important fuel option for heavy-duty vehicles, "there are doubts over its usefulness for lighter passenger cars due to its low degree of efficiency, as lots of energy is lost in the conversion processes when turning electricity from renewable sources into the synthetic fuel with electrolysers."[21] The national hydrogen strategy of the Federal Ministry(2020) states that hydrogen could be an alternative for applications where the direct use of electricity is not practical or technically feasible.[22]

In addition, the efficacy of different technologies in mobility transition has a direct impact on the reduction of CO2 emissions. Therefore, this research field emphasizes the use of full electric solutions as a priority to achieve climate protection goals. The level of emissions caused by EVs

4 https://www.allianzdirect.de/zahlen-daten-fakten/elektroauto-statistiken/

5 https://ecomento.de/2014/01/07/elektroauto-neuzulassungen-2013-die-million-im-blick/

6 https://www.allianzdirect.de/zahlen-daten-fakten/elektroauto-statistiken/

7 https://www.spiegel.de/auto/elektroautos-fast-jeder-dritte-neuwagen-faehrt-vollelektrisch-a-973e56a7-406c-4ce8-867d-014582c3a5a6

8 https://www.agora-verkehrswende.de/veroeffentlichungen/marktentwicklung-von-e-autos/

9 https://www.adac.de/news/elektroautos-deutschland-2023/

10 https://www.agora-verkehrswende.de/veroeffentlichungen/marktentwicklung-von-e-autos/

11 https://www.bafa.de/SharedDocs/Pressemitteilungen/DE/Energie/2022_15_emo_neue_foerderbedingungen.html

12 https://www.bundesregierung.de/breg-de/schwerpunkte/klimaschutz/eenergie-und-mobilitaet/faq-umweltbonus-1993830

13 "The real electric share of driving is on average around 45 - 49 percent for private cars and around 11 - 15 percent for company cars."(https://www.isi.fraunhofer.de/content/dam/isi/dokumente/cce/2022/PHEV_ISI-ICCT_Fact_Sheet_DE-Update-2022.pdf)

depends on several factors, such as energy generation(electricity mix), battery production and capacity, driving performance, and on-board consumers(e.g., seat heaters, air conditioners, and control units).[23] In principle, there are large differences in energy efficiency. BEVs powered by electricity obtained from renewable sources can achieve an efficiency of 90 percent.[24] While BEVs registered today already produce significantly lower life-cycle GHG emissions on average, this is not the case for FCEVs fueled by hydrogen. This is because the primary source of hydrogen today is so-called "grey hydrogen."[25] This results in more modest life-cycle emission reductions of up to 40% less than average medium-sized gasoline vehicles(2021).[26]

Germany's role as an EV manufacturer must also be considered in the context of electromobility. More than half of all E-cars built in Europe are manufactured in Germany.[27] The production figures for e-cars in Germany have increased by 55% compared to 2022.[28] Volkswagen, one of the market leaders, is expected to cease production of ICEs in 2033; by 2029, the company plans to have 75 electric models on the market.[29] This means that German car manufacturers have a significant influence on the European market and, therefore, play a major role in discussions about bans or regulations on combustion vehicles.

The operational readiness of electric vehicles ultimately depends on their technology. These developments are subject to several framework conditions that can inhibit and promote them. These framework conditions include the charging infrastructure, which causes the classic "chicken-and-egg problem."[30] This means that charging point operators will not build charging infrastructure unless there are enough E-cars to demand their services. However, people will not buy E-cars if there are enough charging stations in their area to allow them to charge their cars conveniently.

Various funding and research programs at the federal and EU levels support the development of technologies and provide financial resources bundled into development plans. For Germany, the central instrument is the government's electromobility program, which updates the National Electromobility Development Plan. The aim is to accelerate market preparation and the launch of BEVs. The German government is supported in an advisory capacity in this endeavor by the National Platform for Electromobility(NPE), which was merged into the National

14 https://www.isi.fraunhofer.de/content/dam/isi/dokumente/cce/2022/PHEV_ISI-ICCT_Fact_Sheet_DE-Update-2022.pdf

15 https://www.bundesregierung.de/breg-de/schwerpunkte/klimaschutz/nachhaltige-mobilitaet-2044132

16 https://www.agora-verkehrswende.de/veroeffentlichungen/marktentwicklung-von-e-autos/

17 https://www.bmuv.de/themen/verkehr/elektromobilitaet/effizienz-und-kosten

18 https://www.forschungsinformationssystem.de/servlet/is/ 332825/

19 Data of 2017

20 https://h2me.eu/about/fcevs/

21 https://www.cleanenergywire.org/news/bmw-says-hydrogen-fuel-cells-remain-important-technology-option-passenger-cars

22 https://www.bmwk.de/Redaktion/DE/Publikationen/Energie/die-nationale-wasserstoffstrategie.pdf?__blob=publicationFile&v=7

23 https://www.umweltbundesamt.de/sites/default/files/medien/479/publikationen/texte_160-2022_energieverbrauch_von_elektroautos.pdf

24 https://bdi.eu/artikel/news/e-auto-verbrenner-und-wasserstoff-fahrzeug-im-vergleich/

25 So called grey hydrogen means reforming methane from natural gas

KONRAD ADENAUER STIFTUNG

KOREA TRANSPORT INSTITUTE

Platform "Future of Mobility"(NPM) in the course of 2018, and the Joint Office for Electromobility(GGEMO). The funding areas are distributed across the four federal ministries: the Federal Ministry of Economics and Climate Protection(BMWK), Federal Ministry of Digital Affairs and Transport(BMDV), Federal Ministry of Education and Research(BMBF), and Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection(BMUV).

26 https://theicct.org/sites/default/files/publications/Global-LCA-passenger-cars-jul2021_0.pdf

27 https://www.automobil-produktion.de/produktion/deutschland-faehrt-fertigung-von-e-autos-hoch-395.html

28 https://www.automobil-produktion.de/produktion/deutschland-faehrt-fertigung-von-e-autos-hoch-395.html

29 https://www.adac.de/rund-ums-fahrzeug/autokatalog/marken-modelle/auto/ausstieg-verbrennungsmotor/

30 Among other sources: Puls, T. and Oberst, C. (2018): Ladesäulen für Elektroautos – Ein Henne-Ei-Problem. IW Kurzbericht 49/2018. Institut der deutschen Wirtschaft (IW). Online available: https://www.iwkoeln.de/studien/thomas-puls-christian-oberst-ein-henne-ei-problem-395717.html. Last access: 03.11.2023.

E-Trucks

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In freight transport, the debate on electromobility primarily focuses on the most suitable technical solutions. As with the discussion of EVs, different technologies are available. As already mentioned, hydrogen is a hot topic alongside electric solutions; however, because of its inefficiency, it will probably only be considered for heavy-duty transportation with very high consumption.[1] The efficiencies(WTW, WTT, and TTW)[2] of Fuel-Cell Trucks are significantly lower than those of E-trucks and overhead catenary trucks.[3]

For 2030, an increase in freight volume and a shift in freight volume to rail transport are forecast.[4] Technological progress in propulsion is necessary to counteract the resulting increases in emissions.[5] Long-distance transport is a cost-sensitive market; therefore, economic considerations are the decisive factors. Economic efficiency, acquisition costs, and payback period are a high priority when deciding on the use of a technology. Hybrid and EVs can, in principle, be made to cover or save costs for vehicle operators. A prerequisite for this is a significant reduction in the additional acquisition costs of such vehicles[6]. The major barriers in the discourse on preferred technologies are access to information and financial investment opportunities. The funding program overview for electromobility(see the previous section) also largely applies to freight transport.

Another technology currently being discussed in Germany for freight transport is overhead catenary trucks, which offer several advantages over BEVs. Compared with BEVs, only a quarter to half the size of a battery is required to operate overhead catenary trucks, which is why their payloads are not reduced. These smaller batteries and capacities are sufficient for long-distance transportation; they reduce the tare weight of the vehicle and the corresponding resource requirements. While battery electric trucks require stops for recharging and, therefore, stand still for longer periods, overhead catenary trucks can be recharged while driving, which allows more flexible and continuous use.[7] However, because overhead trucks depend on the overhead line infrastructure network, their routes are constrained.[8]

For this reason, the expansion of the infrastructure for the use of overhead catenary trucks is seen as even more crucial compared to passenger cars("chicken and egg problem").[9] A major challenge is the high degree of fragmentation in the trucking industry, which features

1 Rudolph et al(2019): Strom-und H2-Bedarf für einen dekarbonisierten Verkehrssektor in Deutschland

2 These terms describe different ways of looking at the GHG production of cars. Well-to-wheel(WTW) efficiency can be divided into the observation of well-to-tank(WTT), which measures efficiency from the energy source to the vehicle, and tank-to-wheel(TTW) efficiency, which considers only the emissions of the car itself.

3 Plötz et al(2018): Alternative Antriebe und Kraftstoffe im Straßengüterverkehr – Handlungsempfehlungen für Deutschland

4 Weger et al(2020): Expected impacts on GHG and air pollutant emissions due to a possible transition towards a hydrogen economy

5 Gustafsson et al(2020): Well-to-wheel GHG gas emissions of heavy-duty transports: influence of electricity carbon intensity.

6 Dünnebeil et al(2015): Zukünftige Maßnahmen zur Kraftstoffeinsparung und Treibhausgasminderung bei schweren Nutzfahr zeugen

7 Graichen et al(2020): Klimaneutrales Deutsch land. Agora Energiewende. Agora Verkehrswende

8 Graichen et al(2020): Klimaneutrales Deutsch land. Agora Energiewende. Agora Verkehrswende

9 Gross, Samantha (2020): The Challenging of Decarbonizing Heavy Transport

many small companies and independent operators,[10] creating a special challenge for private investment.

In Germany, testing grounds for overhead trucks already exist. Since 2019, trucks have been driving on a 12-kilometer test route between Frankfurt Airport and Darmstadt using an overhead line and pantographs of the driver's cabin. The route was extended by another seven kilometers from 2022 to 2023.[11]

In this context, the project "AMELIE II" aims to create a technical, economic, logistical, and legal framework for integrating the overhead line infrastructure for electrically powered trucks into the existing infrastructure and to create a suitable billing system.[12] The exchange between the technical, economic, and legal sides as well as the identification of relevant stakeholders and their involvement are the focuses of the project. The project also aims to develop proposals for a uniform legal framework for catenary trucks in Germany and Europe. To this end, the Institute for Climate Protection, Energy, and Mobility(IKEM) conducts legal analyses and develops concrete recommendations for action for the project partners.[13]

10 Gross, Samantha (2020): The Challenging of Decarbonizing Heavy Transport

11 https://www.hessenschau.de/wirtschaft/e-highway-teststrecke-fuer-hybrid-lkw-auf-a5-waechst-um-sieben-kilometer-v1,e-highway-106.html

12 Knezevic et al (2022): Teilstudie 1 – Rechtlich kohärentes Betriebs- und Marktszenario eines Akteursmodells für Electric-Road-Systems. Version 2.0. Erstellt im Rahmen des durch das BMWK geförderten Projektes AMELIE 2. Institut für Klimaschutz, Energie und Mobilität e.V., Berlin

13 https://www.ikem.de/en/projekt/amelie-ii/

E-Buses in public transport

The CO2 reduction potential of buses in relation to the entire transport sector is relatively low because of the small vehicle stock(under 1% in Germany[1]). However, in urban areas, electric buses offer significant opportunities to reduce the environmental impacts of traffic.[2] One study identified three technological strategies for the use of electric buses in public transport:[3]

- Opportunity charging(OC): buses are charged at terminal stations. Because high utilization means that charging times must be short, a high level of charging power is required.
- In-motion charging: overhead buses drive under a power cable. Theoretically, the daily range is unlimited.
- Depot charging (DC): buses usually charge using a manual plug during operating pauses in the depot. The maximum range is 200-300km.

The Clean Vehicles Directive requires transit agencies to procure at least 45% "clean" vehicles(e.g., plug-in hybrid buses), of which at least half(22.5%) must be "zero-emission"(especially battery and fuel cell buses). Beginning in January 2026, the minimum quotas will rise to 65% and 32.5%, respectively.[4]

Many funding decisions for the procurement of electric buses characterize the year 2020(and beyond) in Germany.[5] As with e-trucks, it is also important to consider the economic aspects of the topic because switching to electric buses is associated with high investment costs for bus operators. Therefore, funding is a "game-changer" in terms of reducing emissions from public transportation.

In 2022, 1,884 buses in Germany were electrified. Of these, 85 were overhead buses; 37 were plug-in hybrids; and 145 were fuel-cell buses.[6] Mercedes-Benz was the largest supplier, manufacturing 692 of the buses.[7] The cost of an e-bus is nearly 2-2.5 times higher than the cost of a diesel bus.[8] In addition, the development of infrastructure and the expansion and upgrading of depots require further investment and a considerable amount of additional space.[9] With the Act on the Further Development of the Greenhouse Gas Reduction Quota(GHG quota), transport companies have had the opportunity since the beginning of 2022 to sell CO2 in the form of CO2 equivalents directly or indirectly

1 https://doi.org/10.1016/j.apenergy.2019.01.059

2 https://doi.org/10.1016/j.jenvman.2012.01.012

3 https://www.cambridge.org/core/journals/design-science/article/design-of-urban-electric-bussystems/1C0E4AA05F6E1FBF8A545E13F6A8D2DE

4 https://www.pwc.de/de/branchen-und-markte/oeffentlicher-sektor/pwc-e-bus-radar-2023.pdf, p.8

5 https://trid.trb.org/view/1931931

6 https://www.pwc.de/de/branchen-und-markte/oeffentlicher-sektor/pwc-e-bus-radar-2023.pdf, p.2

7 https://www.pwc.de/de/branchen-und-markte/oeffentlicher-sektor/pwc-e-bus-radar-2023.pdf, p. 3

8 Data of 2017, https://www.busundbahn.de/fileadmin/user_upload/Dossiers/Elektrobusse/DNV_2017_6_Schwarze_FA_WA1.pdf, p.41

9 https://www.pwc.de/de/branchen-und-markte/oeffentlicher-sektor/pwc-e-bus-radar-2023.pdf, p.4

via an intermediary. Up to 15,000€ per fully electric bus can be realized annually through the sale of certificates. The additional revenue possible from carbon trading depends on the GHG quota and the German electricity mix but not on the actual distance the vehicle traveled.[10]

10 https://www.pwc.de/de/branchen-und-markte/oeffentlicher-sektor/pwc-e-bus-radar-2023.pdf, p.6

E-Bikes and E-Scooters

In addition to various restrictions and changes in social life, people's mobility behavior changed significantly during the COVID-19 pandemic. In the short term, many European cities experienced significant changes in their inhabitants' mobility patterns. For example, the use of public transport declined by up to 20% compared to normal levels,[1] while a shift to cycling and walking was recorded. In the summer of 2020, there was a "bicycle boom"[2] in Germany, which was reflected by the low capacities of suppliers and bicycle repair shops. The bicycle industry has grown from 2019-2023 in employment(+30%) and sales figures(+70%)[3] "despite adverse circumstances - such as the corona pandemic."[4]

The same trend applies to bicycle electrification in Germany. During the COVID-19 pandemic, many electric bicycles and e-bikes were purchased in Germany. As reported by the Federal Statistical Office(Destatis), there were approximately 1.2 million electric bicycles in private households in Germany at the beginning of 2021, 20% more than in the previous year. Thus, at the beginning of 2021, there were approximately 7.1 million electric bicycles in households, compared to 5.9 million at the beginning of 2020. These were distributed among just under 5.1 million households, compared to 4.3 million in 2020. This means that approximately one in eight households(13%) in Germany owns at least one electric bike.[5]

E-bikes, particularly electric cargo bikes, play a significant role in freight transportation in urban areas. The key purposes of e-cargo bike use are transportation for kids, leisure, and shopping.[6] The use of cargo bikes in urban logistics, not only in Germany but also in Europe, is gaining support. They are particularly well suited to "last mile" deliveries.[7] The main limitations of e-cargo bike adoption are safety and infrastructure. The social dynamics of use have been identified as the key drivers of e-cargo bike adoption in cities.[8]

Various technical models of cargo bikes are available. They differentiate between the position of the cargo, the maximum payload(up to 500 kg), riding stability, comfort, and, in the case of electric cargo bikes, the battery range and electric assistance.[9] Finally, both cargo bikes and electric vans can reduce CO2 emissions in last-mile deliveries, even after accounting for emissions related to electricity generation.[10]

For private usage, innovation in cargo-bike sharing has not been

1 NTA (2020): Enabling the City to Return to Work. Interim MobilityIntervention Programme for Dublin City. Mai 2020, p.1

2 RND (2020): Boom wegen Corona: In Deutschland werden die Fahrräder knapp. Juni 2020. https://www.rnd.de/wirtschaft/corona-fahrrader-werden-in- deutschland-knapp-T35JRVDP7RF2HPK5PHKKR4BHAU.html(Letzter Zugriff: 15.08.2022)

3 Transportation Think Tank T3 (2023): Branchenstudie zur Fahrradwirtschaft in Deutschland 2019-2022. Beschäftigung und Unternehmensumsätze. Online unter: https://zukunft-fahrrad.org/wp-content/uploads/2023/06/Branchenstudie_zur_Fahrradwirtschaft_2023.pdf (Letzter Zugriff: 15.06.2023)

4 Maier, J. (2023): Fahrradbranche: Lobbyverband fordert Radstrategie von Bundesregierung. Tagesspiegel Background vom 14. Juni 2023

5 https://www.destatis.de/DE/Presse/Pressemitteilungen/Zahl-der-Woche/2021/PD21_38_p002.html

6 https://doi.org/10.1016/j.trip.2022.100705

7 Nürnberg (2018), https://doi.org/10.1016/j.trpro.2019.06.038

8 https://doi.org/10.1016/j.trip.2022.100705

9 Nürnberg (2018), https://doi.org/10.1016/j.trpro.2019.06.038, p.363

10 Llorca, C., Moeckel, R. Assessment of the potential of cargo bikes and electrification for last-mile parcel delivery by means of simulation of urban freight flows. Eur. Transp. Res. Rev.

stimulated by the established bike-sharing operators "although they have the technical knowledge and resources to do so."[11] The field of cargo bike operators in Germany is heterogeneous, differing significantly between regions and cities. Currently, there is no "one-size-fits-all" business model for cargo bike-sharing. Initially, free cargo bike-sharing initiatives were counted on crowdfunding to acquire cargo bikes.[12]

Currently, various German cities support funding programs. Various suppliers(such as greenbikes[13]) offer an overview of current purchase bonuses. In 2023, companies, freelancers, and NGOs in the federal state of Baden-Württemberg were eligible for a 25% subsidy(maximum 2.500€).[14] In the city-state of Bremen, private individuals, small businesses, and NGOs can obtain up to 1,000€ for electric and non-electric cargo bikes.[15]

In addition to e-bikes and cargo bikes, a trend towards e-scooters has been observed since 2019, especially in urban areas. E-scooters, also known as electric stand-up or electric kick scooters, are miniature EVs that have been permitted on roads in Germany since June 15, 2019. At least every sixth person in Germany over the age of 16 years uses e-scooters, but only 45% of them own one, as 55% use sharing services.[16] However, there are no existing or planned funding programs supporting e-scooter ownership in Germany.

Accidents and parking issues with e-scooters have been discussed extensively. The number of accidents caused by incorrect lane use and the influence of alcohol use is increasing.[17] The parking of e-scooters often causes conflict with cyclists or pedestrians, as the scooters are often parked in their limited space.[18] The availability of e-scooters has increased overall demand but has not shifted car traffic to more sustainable mobility solutions. In many cases, e-scooter use leads to a reduction in public transportation users[19] or, like other sharing services, is seen as an additional transport mode.[20] From an environmental point of view, it would be ideal if using an e-scooter for the journey to and from the bus stop("last mile")[21] could facilitate the switch from cars to public transport. However, this applies only to a quarter of all rides.[22]

In addition, the environmental impact of charging shared e-scooters remains uncertain. For example, sharing companies often use a combustion engine van to pick up e-scooters at night to redistribute

13, 33 (2021). https://doi.org/10.1186/s12544-021-00491-5

11 https://www.researchgate.net/profile/Sophia-Becker/publication/330201698_The_Status_Quo_of_Cargo-Bikesharing_in_Germany_Austria_and_Switzerland/links/5c33562792851c22a36248a6/The-Status-Quo-of-Cargo-Bikesharing-in-Germany-Austria-and-Switzerland.pdf#page=168

12 https://www.researchgate.net/profile/Sophia-Becker/publication/330201698_The_Status_Quo_of_Cargo-Bikesharing_in_Germany_Austria_and_Switzerland/links/5c33562792851c22a36248a6/The-Status-Quo-of-Cargo-Bikesharing-in-Germany-Austria-and-Switzerland.pdf#page=168

13 https://www.greenbike-shop.de/blog/lastenrad-foerderung-uebersicht-der-kaufpraemien/

14 https://www.greenbike-shop.de/blog/lastenrad-foerderung-baden-wuerttemberg/

15 https://www.greenbike-shop.de/blog/lastenrad-foerderung-bremen/

16 https://www.adac.de/verkehr/standpunkte-studien/mobilitaets-trends/nutzung-von-e-scootern/

17 https://www.destatis.de/DE/Presse/Pressemitteilungen/2023/05/PD23_N028_462.html

18 https://difu.de/publikationen/2022/e-tretroller-in-staedten

19 Krauss, K.; Gnann, T.; Burgert,T.; Axhausen, K.W. (2024): Faster, greener, scooter? An assessment of shared e-scooter usage based on real-world driving data. https://doi.org/10.1016/j.tra.2024.103997

them across the service area for the next day according to demand. This causes additional trips and energy consumption that must be considered in this context.[23]

Local authorities can also make agreements with rental companies or impose conditions to ensure that e-scooters are available at stations where they support sustainable mobility, for example, by creating cross-connections between public transport stations, particularly in car-dominated districts.[24]

While German cities have no complete bans on e-scooters like the one in Paris,[25] cities such as Berlin are trying to reduce the number of e-scooters in inner city areas. Since September last year, sharing companies in Berlin have had to apply for a so-called "special use permit," which entails paying a fee for each scooter. Berlin aims to reduce the number of e-scooters available to 19,000 scooters from January 2024 to March 2025,[26] a 25% reduction.[27]

20 Krauss, Konstantin et al (2020): Sharing Economy in der Mobilität: Potenzielle Nutzung und Akzeptanz geteilter Mobilitätsdienste in urbanen Räumen in Deutschland, Working Paper Sustainability and Innovation, No. S06/2020, Fraunhofer-Institut für System- und Innovationsforschung ISI, Karlsruhe, https://nbn-resolving.de/urn:nbn:de:0011-n-5829441

21 https://www.umweltbundesamt.de/themen/verkehr/nachhaltige-mobilitaet/e-scooter-momentan-kein-beitrag-zur-verkehrswende#sind-e-scooter-umweltfreundlich

22 https://difu.de/publikationen/2022/e-tretroller-in-staedten

23 https://www.umweltbundesamt.de/themen/verkehr/nachhaltige-mobilitaet/e-scooter-momentan-kein-beitrag-zur-verkehrswende#sind-e-scooter-umweltfreundlich

24 ibid

25 https://www.theguardian.com/world/2023/aug/31/rented-e-scooters-cleared-from-paris-streets-on-eve-of-ban

26 https://www.zeit.de/news/2023-11/09/senatsverwaltung-will-anzahl-von-e-scootern-reduzieren

27 https://www.berlin.de/sen/uvk/presse/pressemitteilungen/2023/pressemitteilung.1383862.php

Autonomous Driving

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Autonomous driving is one of the predominant technologies in Germany for mobility transition. The German government has set the strategic goal of taking a leading role internationally in autonomous driving[1] and becoming a center of innovation.[9] For this reason, the framework conditions for the application of autonomous driving in Germany have recently been further optimized.

Among other measures, the "Act on Autonomous Driving" was passed to enable the regular operation of autonomous motor vehicles of automation level 4[2] in defined operating areas on public roads[6](detailed information on this subject can be found in Chapter 4).

On this basis, research and development shall be further advanced[3] to exploit the potential of autonomous driving. In this context, one of the aims is to maintain German automotive manufacturing and its value chains to secure jobs.[4] In addition, the application of autonomous driving technology is intended to eliminate the shortage of drivers in Germany's public transport system, securing public transport as a climate-friendly mobility option in the long term.[5]

Moreover, new mobility solutions have been created using the technology[6], particularly in rural areas. Furthermore, the technology of driverless driving is intended to enable people with limited mobility, those with reduced ability to operate a vehicle(for example, owing to age, disability, or medication consumption), and those without a driver's license for a conventional vehicle, to participate in general mobility life.[6] These groups of people are to be given increased mobility and thus greater societal participation, which is particularly important given demographic changes that have increased the number of people with limited mobility in Germany.
Overall, the development of technology focuses primarily on safety, efficiency, sustainability, environmental friendliness, accessibility, affordability, and meeting mobility demands.[7]

To achieve these goals and leverage their potential, research on autonomous driving technologies is being funded extensively in Germany. In this regard, the Ministries of Transport, Economics, and Research are the primary actors at the federal level. In particular, the Ministry of Transport supported 72 research projects with funding equivalent to approximately $270 million between 2016 and 2021.[8]

1 https://bmdv.bund.de/SharedDocs/DE/Artikel/DG/gesetz-zum-autonomen-fahren.html

2 Entsprechend des vorherrschenden Rechtsrahmens in Deutschland wird im vorliegenden Artikel das „autonome Fahren" ab Automatisierungsstufe 4 und höher definiert

3 https://bmdv.bund.de/DE/Themen/Digitales/Automatisiertes-und-vernetztes-Fahren/Automatisiertes-und-vernetztes-Fahren/automatisiertes-und-vernetztes-fahren.html

4 https://www.spd.de/fileadmin/Dokumente/Koalitionsvertrag/Koalitionsvertrag_2021-2025.pdf

5 https://www.vdv.de/230124-pm-personalbedarf-anlage-positionspapier-massnahmen-gegen-den-personalmangel-im-fahrbetrieb.pdf.pdfx

6 https://bmdv.bund.de/SharedDocs/DE/Anlage/G/wissenschaftlicher-beirat-gutachten-2017-1.pdf?__blob=publicationFile

7 https://bmdv.bund.de/SharedDocs/DE/Anlage/DG/aktionsplan-forschung-fuer-autonomes-fahren.pdf?__blob=publicationFile

8 https://bmdv.bund.de/SharedDocs/DE/Artikel/DG/forschungsprogramm-automatisierung-vernetzung-strassenverkehr.html

9 https://www.automotiveit.eu/technology/autonomes-fahren/welcher-autobauer-hat-beim-autonomen-fahren-die-nase-vorn-124.html

Regarding technology funding and research, there are numerous test fields, studies, and pilot projects on autonomous driving in Germany. The technology is mainly being used and tested in shuttle buses and passenger cars.

These areas of application are described in more detail below

Passenger Cars

Passenger cars are another area of application of autonomous driving in Germany. All German manufacturers have their own program for development in the field of autonomous driving.[6]

Current developments in passenger car applications are essentially in the area of automated driving up to Level 3.[1] An initial pilot application for autonomous driving already exists at Stuttgart Airport with the option of "valet parking." The driver leaves the compatible vehicle in front of the parking garage, and the vehicle is then parked fully automatically. When the driver is ready to pick the car up, it drives automatically to the pick-up point.[2]

Some German car manufacturers are currently in the process of rolling out new autonomous driving technology applications. For example, from 2024 onwards, further parking situations and applications will be fully automated.[3] In addition, the Mercedes Drive Pilot, which takes over driving completely during traffic jams on highways up to 60 km/h, is to be expanded to a Level 4 application.[4] To date, drivers have always had to take over the driving task again after being prompted by the system.[9]

Furthermore, the Volkswagen Group plans to launch an autonomously driving version of a VW bus in 2025[5], and BMW plans to launch an autonomous vehicle towards the end of the decade.[6]

Technology for autonomous individual vehicles is still in the early stages of development.

"Vision Zero" is a key motivation for the application of autonomous driving technology in road traffic and especially in passenger cars as part of the Mobility Transformation. The overriding goal is to eliminate fatal and serious accidents when designing the future of German road traffic.[7] Because human error is the main cause of road traffic accidents in Germany,[8] autonomous driving is expected to reduce the number of accidents significantly allowing the realization of this vision.

Advanced V2X communication can also help avoid risky situations and accidents.[9] However, low market saturation in the German passenger car fleet and lack of infrastructure are current challenges.[12]
In addition, a stable and permanent data connection is an important prerequisite for the reliable functioning of autonomous driving systems.[10]

1 https://www.automotiveit.eu/technology/autonomes-fahren/welcher-autobauer-hat-beim-autonomen-fahren-die-nase-vorn-124.html

2 https://www.golem.de/news/autonomes-einparken-bosch-und-mercedes-erhalten-zulassung-fuer-level-4-system-2211-170142.html

3 https://www.autobild.de/artikel/autonomes-fahren-in-deutschland-12883819.html

4 https://www.adac.de/rund-ums-fahrzeug/ausstattung-technik-zubehoer/autonomes-fahren/technik-vernetzung/aktuelle-technik/

5 https://fleet-electrified.vwfs.de/e-mob-guide/autonomes-fahren-die-mobilitaet-der-zukunft/

6 https://www.bmwblog.com/2023/09/11/bmw-level-4-autonomous-driving-systems/

7 https://bmdv.bund.de/SharedDocs/DE/Anlage/DG/aktionsplan-forschung-fuer-autonomes-fahren.pdf?__blob=publicationFile

8 https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Verkehrsunfaelle/_inhalt.html#_4qhsjsvau

9 https://www.automotiveit.eu/technology/autonomes-fahren/die-aktuellen-herausforderungen-fuer-das-autonome-fahren-874.html

10 https://bmdv.bund.de/SharedDocs/DE/Anlage/K/presse/010-eckpunkte-gigabitstrategie.pdf?__blob=publicationFile

Connection losses can lead to system failures.[12] In Germany, mobile communication needs to be expanded. For example, it is not possible to obtain a high-performance and stable connection in all regions, and there are still areas where there is no mobile communications coverage at all[13] along highways.[11]

The Autonomous Driving Act currently limits the use of autonomous systems to certain operating areas. For example, the application of an autonomous highway pilot would be limited to approved operating areas; as a result, a long-distance trip through federal territory might not be permissible(for details, see Chapter 4). This restriction is a particular obstacle to the development of autonomous individual vehicles because it has a significant influence on the incentive to buy appropriately equipped vehicles.

Currently, several challenges in Germany stand in the way of more widespread use of autonomous driving technology in individual vehicles.

11 https://www.autobahn.de/die-autobahn/aktuelles/detail/400-neue-mobilfunkstandorte-fuer-die-autobahn

12 https://www.vdv.de/innovationslandkarte.aspx

13 Luchmann, Inga u. a.: Voraussetzungen & Einsatzmöglichkeiten von automatisiert und elektrisch fahrenden(Klein-) Bussen im ÖPNV - Ergebnisse aus dem Forschungsvorhaben LEA(Klein-) Bus. Bundes ministerium für Verkehr und digitale Infrastruktur (Hrsg.), Berlin / Karlsruhe / Hamburg 2019

Shuttle buses

Autonomous shuttle buses are a new vehicle format.[1] Compared to conventional buses, they have smaller dimensions, an electric drive, and various onboard sensors for orientation, vehicle localization, environment perception, and obstacle detection.[2] Figure 2 shows a shuttle used in the test project in Monheim, Germany.

Figure 2. Shuttlebus used in a test project in Monheim, Germany

Source: https://qimby.net/image/Autonom-fahrender-Kleinbus.RWVv

In Germany, autonomous shuttle buses can move freely on prepared and individually approved routes but not more generally on the road networks.[7] For approved routes, a target driving line(trajectory) is defined in preparation for the vehicle's deployment and is read in with the help of onboard sensors. A vehicle guidance system enables a vehicle to move autonomously along the defined route. Currently, there are two main modes of operation of the vehicle guidance system in Germany: autonomous shuttle buses with the operating principle of virtual rail travel exclusively along the trajectory and travel speed adjustment according to the perceived traffic situation. Autonomous shuttle buses based on the functional principle of a "virtual corridor" travel within lined-up imaginary polygons on the road surface.[7]

To date, autonomous shuttle buses in Germany have been used primarily for research purposes in a large number of projects. The focus is on operations in both rural and urban areas, as well as on separate infrastructure and public road transport. There have been 62 autonomous shuttle bus projects initiated nationwide in Germany.[3]

Compared to conventional public transport vehicles, autonomous shuttle buses are characterized by disruptive changes in operating cost structure, thus opening up the scope of operating concepts that are inconceivable under the current economic conditions.[4] In the short term, the cost advantages of autonomous shuttle buses arise from

1 https://gruene-fraktion-lsa.de/fileadmin/images/dokumente/Gutachten_Autonomes_Fahren.pdf

2 Rentschler, Christoph u.a.: Technische und rechtliche Systemgrenzen in der Routenplanung autonomer Shuttlebusse. In: Proff, H. (Hrsg.): Neue Dimensionen der Mobilität, Springer Fachmedien, Wiesbaden 2020, S. 319–331, ISBN 978-3-658-29745-9

3 https://www.vdv.de/innovationslandkarte.aspx

the lower operating costs due to the electric drive. Additionally, the dispensability of driving personnel has economic potential. Depending on the utilization and the transport capacity of an autonomous minibus, the savings potential in this respect amounts to 50-70% of the current operating costs per vehicle kilometer.[9] In contrast, other cost factors of autonomous shuttle buses(e.g., the purchase price of vehicles or costs for additional infrastructure) cannot be reliably predicted because of the comparatively small number of vehicles in use to date.[9] Therefore, the operation of autonomous shuttle buses is not necessarily more cost-effective in all cases.[9] However, the vehicles offer economic potential under certain conditions; based on the current state of research, it can be expected that cost savings will outweigh the cost increases of using autonomous shuttle buses in the medium to long term.

Owing to the economic potential of autonomous shuttle buses, there are two main motives for their use in Germany: the increase in economic efficiency and the improvement of public transport mobility services and public transport services as a whole.

Autonomous shuttle buses can increase the economic efficiency of selected existing public transport mobility services[5] if the operating conditions are favorable for their use. For example, they can be used instead of conventional public transport vehicles at certain times of the day, on certain days of the week, or in specific development areas. The existing public can be maintained[6] but with the addition of some autonomous bus transport, which requires fewer financial resources. This economic optimization can also increase the cost-recovery ratio of the public transport service as a whole. Furthermore, the economic potential of autonomous shuttle buses can also support the expansion and improvement of existing public transport mobility services.[11]

Because of the economic potential of autonomous shuttle buses, the economic viability threshold of public transport mobility services can also be lowered; thus, new transport services can be introduced using autonomous shuttle buses that could not be offered with conventional public transport vehicles.[11] Therefore, the use of autonomous shuttle buses can expand existing public transport services, especially in rural areas.

Autonomous shuttle buses also have the potential to increase the effectiveness, attractiveness,[7] and accessibility of public transport

4 Luchmann, Inga u. a.: Voraussetzungen & Einsatzmöglichkeiten von automatisiert und elektrisch fahrenden(Klein-) Bussen im ÖPNV - Ergebnisse aus dem Forschungsvorhaben LEA(Klein-) Bus. Bundesministerium für Verkehr und digitale Infrastruktur(Hrsg.), Berlin / Karlsruhe / Hamburg 2019

5 Böhler, Susanne u.a.: Handbuch zur Planung flexibler Bedienungsformen im ÖPNV - Ein Beitrag zur Sicherung der Daseinsvorsorge in nachfrageschwachen Räumen. Bundesministerium für Verkehr, Bau und Stadtentwicklung(Hrsg.), Bonn 2009, ISBN 978-3-87994-038-7

6 Perret, Fabienne; Fischer, Remo; Frantz, Holger: Automatisiertes Fahren als Herausforderung für Städte und Regionen. TATuP - Zeitschrift für Technikfolgenabschätzung in Theorie und Praxis,(Hrsg.) Karlsruher Institut für Technologie(KIT) Institut für Technikfolgenabschätzung und Systemanalyse(ITAS), Band/Heft 27, oekom verlag GmbH, Karlsruhe 2018, 2, S. 31–37, ISSN 2199- 9201

7 Chee, Pei Nen Esther; Susilo, Yusak O.; Wong, Yiik Diew: Determinants of intention-to-use first-/last-mile automated bus service. In: Transportation Research Part A: Policy and Practice,(Hrsg.) Elsevier, Band/Heft 139, 2020, S. 350–375.

8 European Environment Agency: The first and last mile - the key to sustainable urban transport. Publications Office of the European Union, Luxembourg 2020, ISBN 978-92-9480-205-7

networks.[11] Under certain conditions, demand shifts from private motorized transport to public transport can be expected,[11] which may result in a decrease in vehicle mileage transport[8] and a reduction in traffic volumes.[9] Particularly in areas that benefit from demand-based service with autonomous shuttles,[10] a reduction in the ownership and use of private cars and ownership of private cars can be expected, which would reduce the need for parking spaces.[12] Thus, another motivation for the development and deployment of autonomous shuttles in Germany is to reclaim land in urban and suburban areas for reuse and mitigate the overall environmental impact of transport.[12]

Currently, however, there are challenges to the use of autonomous shuttles in Germany. Although the law on autonomous driving provides the theoretical basis for the autonomous operation of shuttles in a specific, pre-approved area, for safety reasons, the vehicles are still operated exclusively with a supervisor in the vehicle who can intervene in vehicle control at any time and trigger an emergency stop. Thus, at present, the savings in personnel costs cannot be realized. In this respect, further technical developments are needed in vehicles so that safer operation is possible without on-board personnel. One possible solution is to use a technical supervisor from the back office who can remotely monitor several vehicles simultaneously and intervene if necessary.
In addition, shuttle vehicles used in Germany are susceptible to environmental influences and weather conditions. This is due to the limitations of the sensors used. For example, a LIDAR sensor recognizes the onset of heavy rain or snow as an obstacle, so that the vehicle comes to an immediate stop, despite the absence of barriers to its journey. Therefore, stable and reliable continuous operation is not possible. Promising test projects using AI for object recognition must address these challenges.

A best-practice example of the use of autonomous shuttles in Germany is the "Reallabor Hamburg" test field. Three EasyMile EZ10 shuttles were introduced to cover an area of Hamburg on the city outskirts. More than 1,000 passengers were served over a total distance of 1,325 km. In addition, the passengers rated the mobility service as sufficiently comfortable, reliable, and useful to use again without a vehicle attendant. Thus, autonomous shuttles offer an attractive mobility option that can increase the acceptance of their use.[11]

9 International Association of Public Transport: Autonomous vehicles: a potential game changer for urban mobility. Policy Brief,(Hrsg.) International Association of Public Transport, Brüssel 2017

10 Heinrichs, Dirk: Autonomes Fahren und Stadtstruktur. In: Maurer, M. u.a.(Hrsg.): Autonomes Fahren. Springer, Berlin / Heidel berg 2015, S. 219-239

11 https://osm.hpi.de/diak/Reallabor-Hamburg-Abschlussbericht.pdf

12 https://www.future-mobility-solutions.com/mobility-as-a-service/

Smart Mobility

The progress of digitalization has had a far-reaching impact on the transport sector in Germany. For example, an increasing number of digital applications and processes are being integrated into the planning and operation of public mobility services or are being used in individual vehicles. The combination of technology and mobility to create an increasingly digitalized transport sector is referred to as smart mobility.[1]

Smart mobility aims to achieve seamless, sustainable, and efficient movement of people and goods through the integration of information technologies, artificial intelligence, and data analysis.[2] Smart mobility encompasses the networking and integration of various mobility services, including autonomous vehicles, connected vehicles, intelligent traffic management systems, car sharing, bicycle rental systems, and public transportation, all of which can be connected through digital platforms.[4] Smart mobility applications aim to optimize mobility, improve access to transport, and minimize congestion and the environmental impact of traffic.[5 3]

This development affects not only the means of transport but also the entire transport infrastructure, from autonomous and connected vehicles to intelligent traffic management systems and digital transport platforms. This changes not only the services that people move around but also how traffic flows and resources are managed.

Mobility stations and on-demand services are particularly relevant in the context of digital technology in Germany's transport sector. These aspects are described in detail below.

1 https://www.swarco.com/de/mobilitaet-der-zukunft/urbane-mobilitaet/smart-mobility

2 https://digital-strategy.ec.europa.eu/en/policies/digitalisation-mobility

3 https://link.springer.com/chapter/10.1007/978-3-8349-7117-3_42

4 https://www.hvv-switch.de/de/inhalt/hvv-switch-app/

5 https://bmdv.bund.de/SharedDocs/DE/Artikel/G/mobilitaetsstationen.html

Mobility-as-a-service

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Based on the term software as a service used in the IT sector, mobility as a service(MaaS) refers to the provision of mobility as a service. MaaS reflects the fact that mobility does not require owning a vehicle; instead, vehicles such as cars, bicycles, and scooters, can be hired.[1] MaaS solutions usually bundle the services of several providers in one app, which can be used to book routes, vehicles, and tickets.[2]

A user-centered approach should ensure that an attractive service tailored to user needs is available at all times. This reduces the need to own a private vehicle, lowering the impact of transportation on the environment.[3] For example, less private car ownership in a residential area could reduce the need for parking spaces, freeing space for attractive use. Owing to the bundling of different means of transportation, MaaS solutions in Germany are often used in combination with mobility stations(see the following section).

A best-practice example is the "hvv-switch" app available in Hamburg. It can be used to book car-sharing vehicles, bikes, scooters, tickets for public transport, and on-demand mobility services(see On-Demand Mobility below) from various providers. Access and billing are handled using a single account.

As an additional incentive to use the app, public transport tickets are sold at a seven percent discount compared with other retail channels.[4]

1 https://www.future-mobility-solutions.com/mobility-as-a-service/

2 https://www.hacon.de/portfolio/mobility-as-a-service/

3 https://blog.frankfurt-holm.de/beitrag/mobility-as-a-service

4 https://www.hvv-switch.de/de/inhalt/hvv-switch-app/

Mobility Stations

Mobility stations are an integral part of German cities' efforts to shape a sustainable and efficient transport future. These multifunctional hubs integrate various mobility services to enable the seamless linking of public transport, car sharing, bicycle rental, and electromobility.[1]

They act as interfaces that not only make it easier to switch between modes of transportation but also improve access to different mobility services. By linking different transport services, they reduce the use of privately owned vehicles and promote the sustainable and efficient use of resources and infrastructure.[2]

One promising example of mobility stations in Germany is "Jelbi" in Berlin. Jelbi combines different mobility services from various providers, including public transport, e-scooters, bikes, and car-sharing services, on a single booking platform.

There are also Jelbi stations at central locations throughout Berlin where users can flexibly switch between different modes of transportation[3], such as renting a bike-sharing bike for the last mile after a subway ride. The Jelbi application also allows users to plan an optimal combination of transport along their routes.[4]

Figure 3. Mobility station for hiring cars and scooters in Mannheim(Germany).

Source: https://qimby.net/image/Mobilitätsstation-Mannheim.kaUT

1 https://bmdv.bund.de/SharedDocs/DE/Artikel/G/mobilitaetsstationen.html

2 https://www.deutschebahnconnect.com/produkte/curbside_management/content/Whitepaper_Design-Thinking-Workshop%20DB%20Curbside%20Management_HOLM_01-2022.pdf

3 https://www.berlin.de/tourismus/infos/verkehr/sharing/6983603-4550357-sharing-jelbistationen-der-bvg.html

4 https://www.jelbi.de

On-Demand Mobility

In public transport, on-demand mobility is an innovative, flexible form of technology-based service. Vehicles do not follow a fixed route or timetable; instead, they travel flexibly to virtual stops and along routes within a service area according to user demand.[4] The vehicles run "on demand" and are usually ordered via an app.[5]

This basic operating concept has been in use in Germany for some time. However, the increasing use of mobile devices[6] has improved the conditions for communication between users and ride providers. In addition, intelligent algorithms can be used to combine registered travel requests optimally at any time, making operations more efficient.[10]

This flexible mobility can be an important element in the mobility transition.[11] The implementation of on-demand mobility services, especially in densely populated areas, can reduce the use and ownership of private cars.[3] This reduces the need for parking spaces in decentralized locations(e.g., residential areas) as well as in central locations(e.g., city centers), freeing up space for multifunctional uses or greening.[3] This means that on-demand mobility services can contribute to land redevelopment in urban and suburban areas.[2] Therefore, the reduction in the number of private cars and the overall traffic mileage can moderate the environmental impact of traffic.[1] In rural areas, on-demand services can be used to make regional public transport services more attractive and thus ensure greater mobility for the population, regardless of whether they own a vehicle or have a driver's license.[7]

A best-practice example for on-demand services in Germany is "hvv hop" in Hamburg. The application uses bookable, flexible ride services to and from the stops of the main public transport system in districts that are densely populated or located on the outskirts of the city and are only marginally covered by public transport.[8]
The service is integrated into the public transportation system and can be used for a small surcharge on public transportation tickets per journey and per person.[9] Owing to its innovative approach, the project was awarded the German Mobility Prize in 2019.[10]

The combination of autonomous driving technology and autonomous vehicles creates potential for further innovative public transport mobility services.[1] As driver availability is no longer a prerequisite for operating vehicles, services can be provided even more flexibly.[1]

1 https://osm.hpi.de/diak/Reallabor-Hamburg-Abschlussbericht.pdf

2 https://www.future-mobility-solutions.com/mobility-as-a-service/

3 https://www.hacon.de/portfolio/mobility-as-a-service/

4 https://ioki.com/was-ist-eigentlich-on-demand-mobilitaet/

5 https://www.vdv.de/ondemandumfrage22.aspx

6 https://de.statista.com/statistik/daten/studie/198959/umfrage/anzahl-der-smartphonenutzer-in-deutschland-seit-2010/

7 https://www.vdv.de/92-leitfaden-bedarfsverkehr-v4.pdfx?forced=true

8 https://www.hamburg.de/hvv/11605804/ioki-hamburg/

9 https://ioki.com/project/ioki-hamburg/

10 https://nachhaltigkeit.deutschebahn.com/de/news/ioki

This means that in the future, there is also the potential to offer public transport mobility services 24 hours a day, seven days a week,[2] which can further increase the attractiveness of public transport and boost the modal shift.

Conclusion

The electrification of transport is a key technology in the mobility transition, particularly in passenger transport. Electrification is also important in freight transport using trucks, although discussions about which technologies to use in certain applications are not yet complete. Autonomous driving technology has promising applications for the mobility transition. To achieve widespread use in Germany and overcome the challenges described above, R&D needs to be further expanded. With the increasing spread of smart mobility solutions, both new and existing mobility services can be interconnected and designed more efficiently. Thus, further positive effects in terms of mobility transitions can be expected.

However, the discussion of which technologies should be promoted and which will dominate in the future continues, hindering the rapid application of some technologies in Germany's transport sector. Particularly with regard to Germany's climate goals, decisions must be made quickly to close the climate target gap and catch up with other countries.

Accordingly, the reduction of emissions in transport must be driven forward more strongly through both propulsion transition and the reduction of traffic. Electrification, autonomous driving, and smart mobility solutions can contribute to passenger transport in this regard. There are also promising technologies in freight transport, such as the shift from road to rail, which can accelerate the mobility transition. However, further measures and intelligent applications, particularly traffic reduction, must be identified.

A variety of technologies related to the mobility transformation already exists in Germany. Although some of these still need to be further developed for broader applicability, they have the potential to play a major role in achieving a more climate-neutral transport sector. Therefore, public acceptance must be secured, suitable applications of the technologies must be assessed, and the subsidization of promising technologies must be expanded so that they can be utilized in a goal-oriented and profitable manner towards a more climate-neutral transport sector in Germany.

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Technological Aspects of Mobility Transformation in South Korea

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Introduction

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As mentioned in Chapter 1, the mobility transformation will have three key features: 1) decarbonization through electrification of mobility objects, 2) automation of mobility objects, and 3) sharing and integration of mobility objects through Mobility as a Service(MaaS). Understanding the technological status of the three fields is, thus, important.

First, mobility electrification involves reducing the use of fossil fuel-based energy by traditional means of transportation and switching to renewable energy-based fuels that emit less CO_2. The greatest motivation for electrification is the global policy effort to reduce greenhouse gas (GHG) emissions and prevent climate change. According to the UN, more than 70 countries, including China, the USA, and the members of the EU, have established net-zero goals, and over 3,000 industries and financial institutions are attempting to reach science-based targets for reducing GHG emissions (UN, 2023).[1]

Second, South Korea seeks to implement autonomous-driving-based mobility services in the daily lives of its citizens by commercializing the world's highest level of fully autonomous driving(Level 4) by 2027. Autonomous driving and cutting-edge infrastructure will enable South Korean citizens to relax, work, and engage in cultural activities in moving vehicles as part of their daily routines. Additionally, this change is intended to solve social and economic problems, such as accidents and traffic congestion. By 2035, South Korea's goal is to popularize fully autonomous driving, achieving more than 50% penetration of new autonomous vehicles. Ultimately, South Korea's goal is to reduce traffic accident deaths from 2,916(2021 level) to less than 1,000 and reduce traffic congestion by 30% compared with the current level.

Third, the South Korean government recently unveiled the "Mobility Innovation Roadmap"(September 2022) and announced the full-scale promotion of Korea Mobility as a Service(K-MaaS)[2] on a nationwide basis through the establishment of an integrated management system for various mobility data. In addition, local governments(including Incheon, Bucheon, Gyeonggi-do, Gangneung, and Gangwon-do) and private companies are promoting R&D and pilot operations of user-tailored services based on a shared/integrated mobility(MaaS) platform through the government's Smart City Challenge project.

These services are scheduled to be developed and operated as core

1 UN(2023), Climate Action, Source: https://www.un.org/en/climatechange/net-zero-coalition

2 Full-scale promotion of the Mobility Innovation Roadmap and K-MaaS project(Ministry of Land, Infrastructure and Transport; September 19, 2022)
- Support private sector-led MaaS activation by establishing an integrated management system for various data on connected mobility services and sharing it with the private sector
- Achieve travel across the country in 2 hours through MaaS implementation on a national scale by connecting all mobility services including public transportation, railway, personal mobility, rental cars, and taxis

mobility services in national pilot smart cities(e.g., the Sejong 5-1 Living Area and Busan Eco-Delta Smart City).

This chapter presents a detailed review of the technological aspects of electrification, automation, and sharing/integration.

Current status of electrification

The South Korean government's eco-friendly vehicle support policy was institutionalized in law in 2004, with the Act on Promotion of Development and Distribution of Environment-Friendly Motor Vehicles. The act stipulates that the Ministry of Trade, Industry, and Energy will promote the development of relevant technologies, whereas the Ministry of Environment(ME) will promote the distribution of environmentally friendly vehicles. In the early stages, eco-friendly vehicle technology was mainly developed around hybrid vehicles and low-emission diesel vehicles; however, as electric vehicle(EV) models have been available in the South Korean market since 2010, subsidies and public sector support projects, including infrastructure construction, have been targeted toward EVs. In the power field, the Jeju smart grid test-bed project has been promoted since December 2009, whereas EV test-bed projects have been conducted in the smart transportation field. Consequently, a charging infrastructure was built around the Jeju Smart Grid Test-bed, and an EV business ecosystem emerged.

The South Korean government developed carbon-neutrality scenarios in October 2021 to reach net-zero emissions by 2050. The carbon neutrality scenario for the transportation sector consists of reducing energy demand by 59.4%–64.9% and GHG emissions by 90.6%–97.1%, compared to 2018 levels by 2050. Key reduction measures include demand management to reduce passenger car traffic and mobility electrification through EVs and hydrogen vehicles.

The government promotes electrification of the transportation sector not only on roads but in all transportation domains, including railways, shipping, and aviation. However, the road domain accounts for the overwhelming majority of GHG emissions in South Korea at 94.8%, making it the focus of electrification efforts.

Mobility electrification converts the final energy consumed from fossil fuels into electricity. Existing internal combustion engine vehicles(ICEVs) are replaced with battery electric vehicles(BEVs) or fuel-cell electric vehicles(FCEVs). Currently, the transition to electrification in South Korea is being promoted with a focus on BEVs and FCEVs. In Europe and the USA, plug-in hybrid electric vehicles(PHEVs) equipped with internal combustion engines(ICEs) are also used as a means of electrification; however, in South Korea, the share of PHEVs is low, and they are classified as general hybrid vehicles (HVs).

There were approximately 430,000 BEVs and FCEVs registered in South Korea at the end of 2022, as shown in Table 1. Among the new passenger cars in 2022, BEVs accounted for 10.8% and FCEVs accounted for 0.7%. The share of FCEVs is increasing.

Table 1 *Number of BEVs and FCEVs registered in South Korea as of Dec. 31, 2022*

Vehicle type		First Release	Model availability	OEM	No. of registered vehicles	Description
BEV	Car	2009	60+	Domestic, Imports	315,675	
	Bus	2017	50+	Domestic Imports (mainly China)	5,220	Urban transit
	Truck	2019	30+	Domestic Imports (mainly China)	81,507	Delivery van, cargo truck (less than GVWR 3.5 tons)
FCEV	Car	2019	1	Hyundai	29,445	Nexo model
	Bus	2019	2	Hyundai	283	Eleccity model
	Truck	2023	2	Hyundai	5	Efficient model

Technical elements of electrification

Vehicles

Vehicles are the most basic technical elements of electrification. Because BEVs and FCEVs use electric power, their structures differ from those of ICEVs. BEV motors are supplied with electricity from batteries, whereas FCEV motors are supplied with electricity generated by combining hydrogen and oxygen in a fuel cell.

Batteries are the key components of BEVs, and their capacity determines the vehicle's driving range. In the early stages of the market, driving range limitations and the inconvenience of charging due to battery technology were the biggest obstacles to switching to BEVs. However, recent improvements in battery energy density and faster charging speeds have increased the number of models that can drive more than 400 km on a single charge.

FCEVs can share most of the electrification components with BEVs, but they use hydrogen storage and fuel-cell systems for fuel supply. A hydrogen storage system is a device that stores high-pressure hydrogen and controls its pressure; current designs can withstand pressures over 700 bar. A fuel-cell system consists of a fuel-cell stack; control units that supply and control hydrogen and air to the stack and remove the generated water and heat; and electronic devices that supply electricity generated from the stack to the motor and control power.

The range of BEV models offered is gradually expanding from small cars, including passenger cars and small commercial vehicles, to include heavy-duty vehicles(HDVs) However, HDV models are still limited. In South Korea, the HDV segment is expected to switch mainly to FCEVs because of their advantages in terms of energy storage. However, delays in the development of battery technology and the commercialization of FCEVs have allowed BEV models to remain in the market.
Both battery electric buses(BEBs) and fuel-cell electric buses(FCEBs) are commercially available in South Korea. BEBs and FCEBs have different charging methods, charging times, and driving ranges on a single charge.

In the South Korean truck market, the conversion of HDVs to EVs is being promoted, with a focus on FCEV models. Currently, fuel-cell electric trucks(FCETs) produced by Hyundai Motor Company have a payload capacity of 11 tons but are not yet being operated in large numbers. Hyundai Motor Company has exported medium-duty battery-electric trucks(BETs) with a payload capacity of 3 tons overseas but has no plans to launch them domestically.

Electric vehicle(EV) charging infrastructure

One of the biggest challenges in switching to EVs is supply issues with the charging infrastructure. In South Korea, the public sector first led the establishment of charging infrastructure to spread BEVs and FCEVs, but the lack of charging infrastructure remains one of the biggest obstacles to electrification.
BEVs can be charged with alternating current(AC) or direct current(DC). AC charging is mainly conducted through an on-board charger(OBC) or wireless charging device within EVs, and the charging capacity ranges from 3.7–11 kW for OBC charging and from 3.2–11 kW for wireless charging. DC charging is a method of directly charging batteries with a

DC power of 40 kW or more using an external charger.
BEVs are mainly charged during downtime, when the vehicle is not being driven, rather than during the journey. However, because most people in South Korea live in apartment complexes, the availability of home charging is relatively limited. Accordingly, the South Korean government has promoted the installation of public chargers since the initial distribution stage.
Public chargers, which are currently being installed, include slow chargers for AC charging and fast chargers for DC charging. The installation of fast chargers is expanding from the initial 50 kW fast chargers to the current 400 kW ultrafast chargers. The South Korean DC charging standard is CCS Type 2. The initial charging point operators were established and operated primarily by public institutions. However, private operators' participation has gradually increased. By the end of 2022, 38% of public fast chargers and 96% of public slow chargers were operated by the private sector, indicating a transformation into a private-sector-led market. As of the end of 2022, over 200,000 public chargers have been installed in South Korea, approximately one for every two BEVs.

Table 2 *Number of newly installed public chargers in South Korea by year.*

Infrastructure type	2018	2019	2020	2021	Total
Public slow chargers	5,213	2,183	2,409	5,262	20,737
Public fast chargers	22,139	15,257	16,987	37,251	184,468

Charging infrastructure models for commercial vehicles, including BEBs, have been developed primarily for garages. Typically, the charging infrastructure for regular-route buses requires a large-capacity charging system. Examples currently built include an 8,000 kWh charging system combined with photovoltaic power generation, as shown in Figure 7.
In South Korea, as the scale of EVs is gradually increasing, their use as flexible resources in the power grid is under consideration. For example, vehicle-to-grid(V2G) technology charges EVs during the day when renewable energy generation is high, and discharges the energy stored in EV batteries back to the grid during on-peak use hours. It is expected that V2G will allow the balancing of supply and demand in electric power systems, avoid the construction of new power plants, and reduce CO_2 emissions.

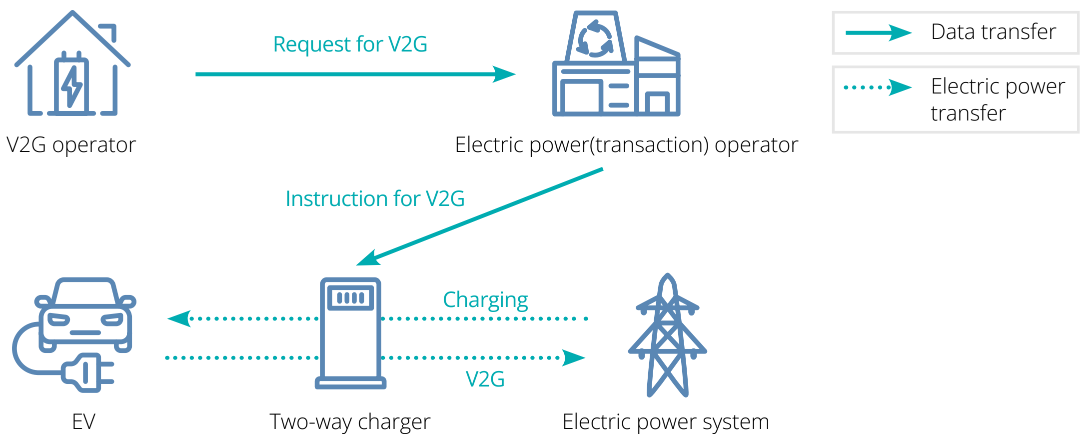


Figure 1. Example of charging infrastructure for BEBs.

Source: Pumpkin's website; https://www.epumpkin.co.kr/business/ev-infra/

Hydrogen refueling stations

Hydrogen refueling stations(HRSs) in South Korea began to be built after the government announced the "Hydrogen Economy Roadmap" in 2019. By the end of 2022, 229 HRSs were operational. HRSs currently in operation are mainly off-site stations, storing and delivering hydrogen byproducts from industrial complexes. Initially, HRSs were built on a small scale with a refueling capacity of 25 kg/h. However, as the scale of FCEVs gradually expands and the number of HDVs, including buses and trucks, increases, new higher-capacity HRSs are being built. The HRSs currently being built in Sejong City will have a capacity of 300 kg/h and will be used for refueling FCEBs

Table 3 *Number of newly installed hydrogen refueling station in South Korea by year*

2018	2019	2020	2021	2022	Total
14	22	34	100	59	229

Source: Hogil Lee (2020), KATECH Mobility Insight, September 2020 issue, pp.16

However, considering that switching to FCEVs ultimately aims to reduce dependence on fossil fuels, the current approach of utilizing by-product hydrogen is not sustainable. Therefore, future HRS technologies must be improved to expand the production of green hydrogen from renewable sources. For byproducts or reformed hydrogen, which are being used in transitional technologies, efforts should also be made to reduce carbon emissions by utilizing carbon capture technologies.

In addition, the current approach to producing and delivering gaseous hydrogen faces issues of space-limited applications and economic feasibility as the scale of FCEVs increases. Thus, a business model for liquid hydrogen refueling stations(LHRSs) has been proposed based on domestic energy providers. The model is an approach that involves storing and transporting hydrogen liquefied from gaseous form at a cryogenic temperature below -253 °C, which is expected to increase the efficiency of the fuel supply system. In South Korea, the liquefied hydrogen plants of Doosan Enerbility, SK E&S, and Hyosung Heavy Industries are scheduled for completion in 2023.

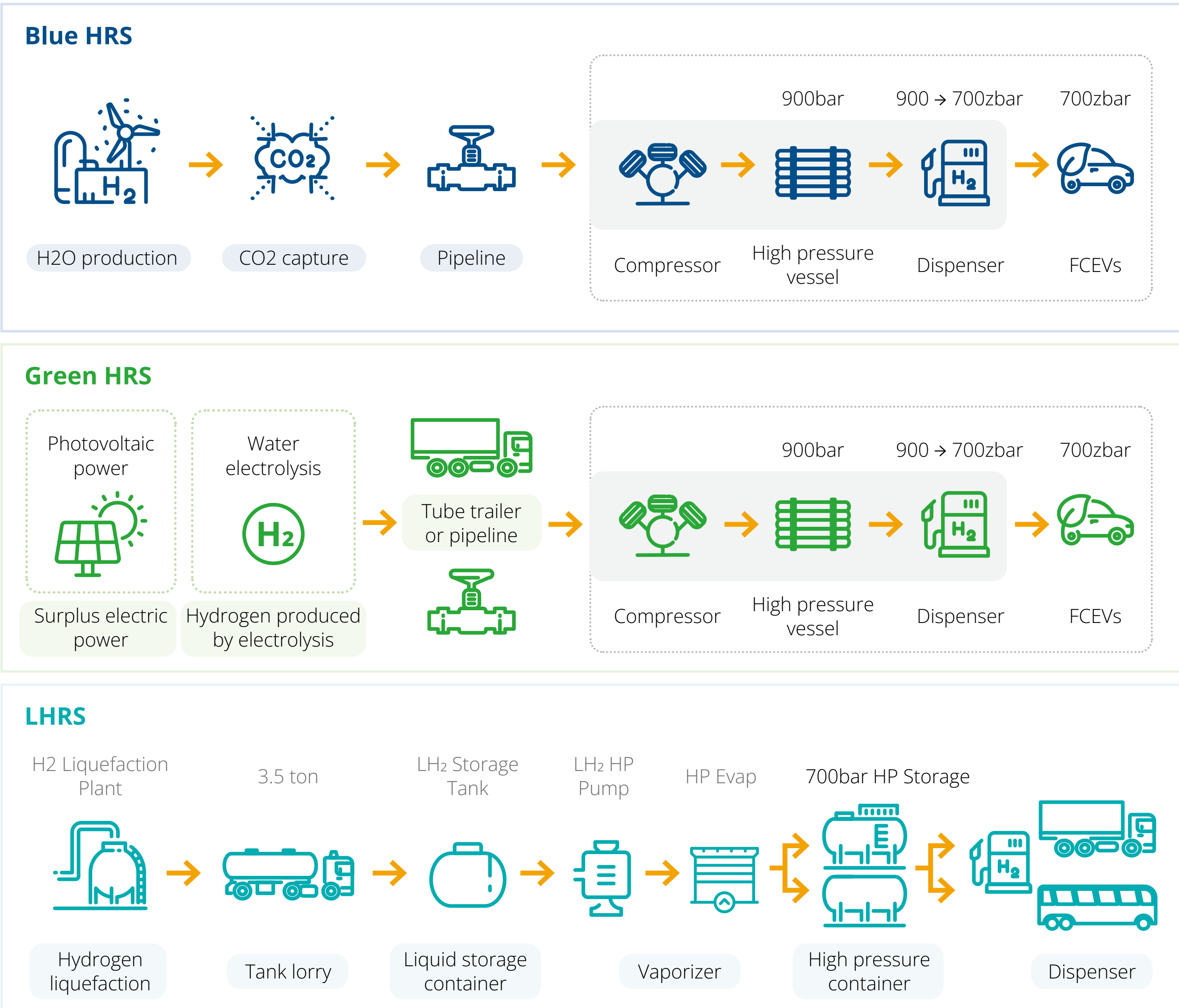


Figure 2. Future HRS models in South Korea.

Source: Kohygen; .gasnews.com/news/articleView.html?idxno=96002

Electrification policy and prospects

The South Korean government is pursuing policies that will support the transition to EVs, including financial support, such as subsidies and tax breaks, and projects to establish charging and refueling infrastructure. First, financial support for technical development and technology distribution of eco-friendly vehicles including BEVs and FCEVs is provided through the Act on Promotion of Development and Distribution of Environment-Friendly Motor Vehicles. Currently, subsidies paid to eco-friendly vehicles and construction projects for charging or refueling infrastructure are being promoted to reduce GHG emissions and other air pollution; these are provided through the Clean Air Conservation Act. In addition, the support system for charging-point operators is provided the Smart Grid Construction and Utilization Promotion Act.

As for the support system currently in effect, benefits provided to EV buyers and manufacturers include subsidies and tax credits for vehicle purchases and reductions in parking and toll fees, while partial or full support for the cost of installing chargers is offered to charging-point operators. As an indirect regulation, manufacturers are required to sell a certain minimum percentage of EVs in their offerings in accordance with Motor Vehicle Average Fuel Economy Standards, Greenhouse Gases Emission Standards, and Mandatory Supply Targets for Low-Emission Vehicles. To boost demand, a system has been also introduced that requires the public sector and private businesses to purchase EVs above a certain percentage of their total vehicles.

Table 4 *Support policy for transition to EVs in South Korea.*

<table>
<tr><th colspan="2">Classification</th><th>Light-Duty
(less than 3.5 tons)</th><th>Heavy-Duty
(3.5 tons and more)</th></tr>
<tr><td rowspan="3">Support system</td><td>Manufacturers</td><td colspan="2">(Indirect) Subsidies for EV or FCEV purchase</td></tr>
<tr><td>Consumers</td><td colspan="2">Subsidies and tax credits for EV or FCEV purchases; and transportation cost reduction benefits</td></tr>
<tr><td>Charging point operators</td><td colspan="2">Support for the cost of installing chargers</td></tr>
<tr><td rowspan="2">Regulatory device</td><td>Manufacturers</td><td>Motor Vehicle Average Fuel Economy Standards and Greenhouse Gases Emission Standards; Mandatory Supply Targets for Low-Emission Vehicles</td><td>-</td></tr>
<tr><td>Consumers</td><td colspan="2">Mandatory Purchase and Rental of Low-Emission Vehicles(public sector); Mandatory Purchase of Environment-Friendly Vehicles(public sector); and Mandatory Purchase Targets for Environment-Friendly Vehicles(public and private sectors)</td></tr>
</table>

The ultimate goal of electrification in the transportation sector is carbon neutrality. South Korea's carbon neutrality scenarios include Plan A, which replaces 97% of all cars with EVs by 2050, and Plan B, which replaces 85% of all cars with EVs by 2050. The National Basic Plan for Carbon Neutrality and Green Growth, announced in 2023, sets the goal of supplying 4.2 million BEVs and 0.3 million FCEVs by 2030. Therefore, considering the policy goals announced by the South Korean government, electrification of road transportation is expected to progress rapidly.

Composition of Automated Driving System

Automated driving enables a vehicle to drive on its own, without human drivers, through a process of perception, judgment, and control based on an automated driving system(ADS). Depending on the technology used, automated driving can be divided into six levels(0–5): Generally, automated vehicles(AVs) are those with Level 3 automated driving or higher, whereas Levels 1– 2 vehicles are considered advanced driver assistant systems (ADAS).
The core of automated driving is the ADS, which is a convergence system of the hardware and software of the sensors installed in the car. In other words, the ADS determines and controls various dynamic driving tasks by recognizing objects based on data collected from LiDAR, radar, cameras, GPS, etc.(hardware) and by judging driving conditions through an artificial intelligence(AI) based computing system(software) or electronic control unit(ECU).

LiDAR (Light Detection and Ranging)

LiDAR works by sending laser signals from a given location to measure the real-time location and distance of objects based on how long it takes the signal to be reflected after hitting the objects. It can estimate the 3D shapes of objects by measuring them in 360 degrees. The technical level is based on the accuracy and measurement range of the position and shape of the object according to the number of channels. The measurement range of LiDAR is usually 100–200 m. However, it has recently been expanded to 300 m or more.

Due to its excellent mapping ability, LiDAR has the advantages of high resolution and predictability. Mapping is a function used to calculate and predict the positions of static and dynamic objects. Therefore, LiDAR is mainly used for obstacle avoidance so that AVs can drive in a stable and safe manner. However, its disadvantages are its cost and its reliance on reflected signals. However, the price is expected to decrease as ADAS vehicles become more widespread and AVs are commercialized in the future.

Radar

Unlike LiDAR, radar collects distance(position) and speed information based on signals reflected from objects using electromagnetic waves. Thus, although radar cannot clearly recognize the shape of objects, it provides accurate location and speed information, regardless of the weather or time.

Radar can detect anything at short, medium, or long distances depending on the sensor function. Short-range radar detects objects within 100 m with a wide field of view of 100 degrees or more, whereas mid- and long-range radar can identify objects at distances over 150–200 m with a narrow field of view of approximately 40 degrees.

Ultra-short-range radar(USRR), a newer type of radar, uses ultrasonic waves and has low detection ability for moving objects. This is because ultrasonic waves are sound waves that use air as a medium; therefore, they are affected by environmental factors including temperature, humidity, and wind. However, USRR, which compensates for these shortcomings, is being installed in ADAS vehicles to enhance the function of the driver assistant system.

Camera

Cameras have lower accuracy than other sensors and are greatly affected by weather conditions; however, they are cheaper than LiDAR and can collect color and shape data. Therefore, the vast amount of data detected by cameras from various locations of vehicles is not only used for recognizing visible objects based on AI and deep learning.

Notably, a camera mirror can replace the conventional side/rear mirror, and ADAS technology can recognize surrounding objects and traffic situations with a camera outside a vehicle and provides this information to the driver or passengers. These innovations have begun to be commercialized. Furthermore, camera technology enables ADSs/ADASs to learn images of various environments and conditions on their own to increase object recognition rates and even analyze and predict the movement patterns of surrounding vehicles and people.

Automated driving technology, and solutions to overcome its limitations

Automated driving technology(ADT)

The driving technology implemented by ADS-based AVs addresses

dynamic driving tasks, which consist of three functions: operational, tactical, and strategic. Operational functions are basic driving skills that include steering, braking, accelerating, and monitoring of vehicle and road conditions. Tactical functions are driving skills to change lanes, turn left/right, make a U-turn, and use signals in response to road conditions and events. Strategic functions are a series of functions that automatically drive to an intermediate point or destination, including the entire travel process.
Within the operational design domain(ODD), where such dynamic driving tasks are performed based on ADS, Level 3 is ADT, in which a human driver, not ADS, can switch control of the vehicle to manual driving (disengagement) and change it to automated driving again. Level 4 can be distinguished from Level 3 in that it is ADT in which ADS, not a human driver, directly guides and maneuvers to minimize risk by switching control of the vehicle. Regardless of the ODD, the ADT in which a vehicle operates based on ADS in any situation or area can be considered as Level 5.

Limitations of automated driving technology and solutions to overcome them

Most importantly, the common physical limitations of ADS are that the sensors may fail due to dynamic factors, including objects outside the detectable spatial range, blind spots, differences between day and night, and bad weather. In addition, they must be able to detect in real time and make decisions quickly through their own processing; however, their processing time or errors for a range of atypical objects(e.g., pedestrians, the transportation vulnerable, cyclists, potholes, and pavement conditions) may cause delays in their perception and judgment.

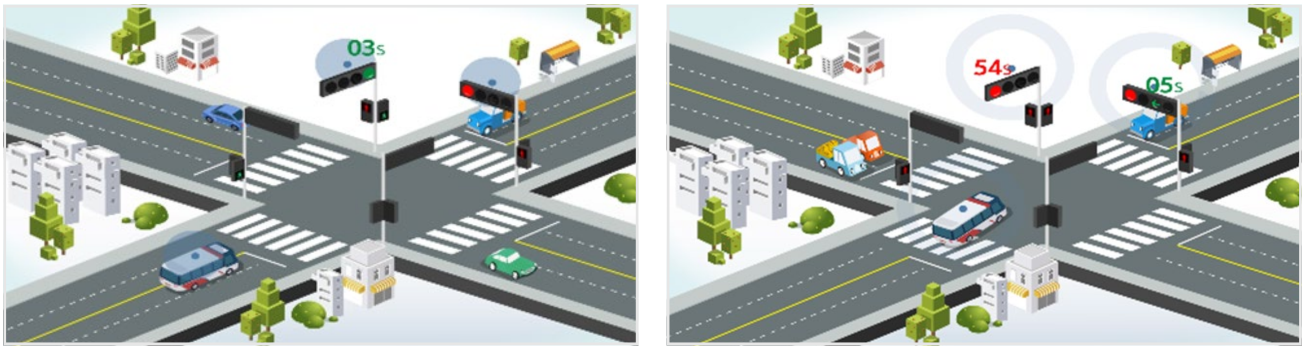
The key point in Levels 3 and 4 is that the roles of the driver and system are differentiated in ODD depending on whether errors in the ADS might occur. In this regard, the limitation of automation Level 3 is the driver's lack of response ability. Because each driver’s driving behavior, habits, and ability to switch vehicle control are different, ADS is not yet at the stage where it can be universally applied to all drivers. The limitation of Level 4 is errors in the ADS, which are considered to be temporal and spatial limitations of the major sensors that compose the ADS described above in monitoring road traffic conditions in real time.

Automated driving services based on C-ITS technology

Safe passage support services based on on-site C-ITS (V2V & V2I)

Figure 3 shows a service that enables AVs(vehicles) to receive signal phase data(right-of-way signal) suitable for the direction in which they approach the signal at an intersection(via vehicle-to-infrastructure(V2I) communication) and safely stop, go straight, or turn left or right according to the data.

The service allows them to receive the signal phase data from the signal at a single crosswalk and stop, pass, and start.



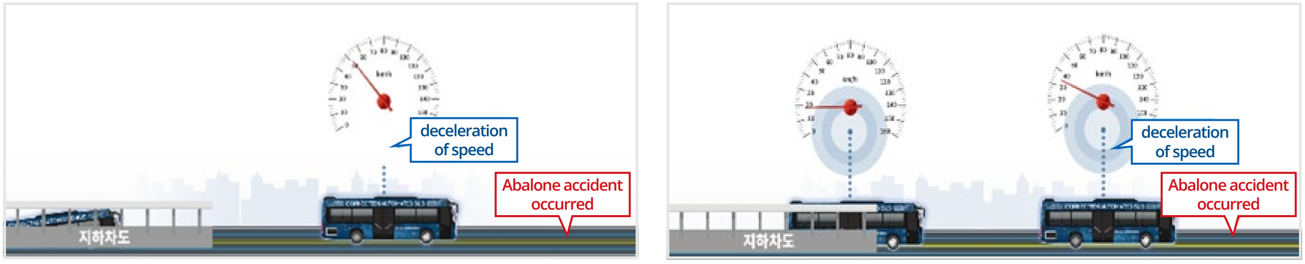
Right-of-way to stop traffic(up and down) when going straight(left and right)

Right of way to turn left(up and down) when stopped(left and right)

Figure 3. Conceptual diagram of automated driving service based on V2I communication.

Figure 4 shows an example of service safety. An AV in front stops while the sight distance of the AV following behind is reduced by an underpass. The AV in the rear can receive the location and speed data of the vehicle in front via vehicle-to-vehicle(V2V) communication and calculate the driving speed for a safe approach.

In addition, when the AV in front makes an emergency stop due to an unexpected incident while driving(e.g., emergency lights on), the AV behind can receive an emergency warning and location and speed data via V2V communication and calculate the driving speed for a safe approach.



The sight distance of the vehicle behind is obstructed by an underpass.

The vehicle behind(underpass) reduces the approach speed through V2V communication with the vehicle ahead.

Figure 4. Conceptual diagram of the adaptive cruise control service based on V2V communication.
Underpass/ Deceleration/ An incident at the vehicle ahead

Automated driving services based on traffic control center-to-vehicle communication(V2C)

Figure 5 shows another example of service safety. When the traffic control center detects a problem related to an unexpected incident or the possibility of a problem occurring in the transportation network, it provides relevant data to the AVs via vehicle-to-center(V2C) communication. Based on this communication, control of the vehicle can be switched from the ADS to a human driver. After control has been switched from the system to the driver and the problem is resolved, control can be switched from the driver to the system again.

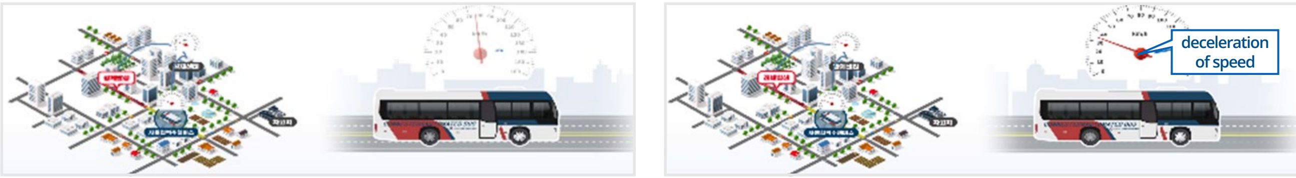
The ability to switch control of AVs is the most important safety requirement at ADS Level 3. The traffic control center supports a front-view monitoring function for driver safety, ensuring sufficient time to switch control when necessary for safe driving.

Before switching control (manual driving)

After switching control (automated driving)

Figure 5. Conceptual diagram of safe switching of control based on a traffic monitoring system.

Figure 6 shows the support services for driving speed to determine traffic conditions. If the traffic situation in the road section that an AV(vehicle) is trying to enter cannot be recognized by the vehicle because of the temporal/spatial limitations of the ADS, the traffic control center, which determines the traffic situation through the nearby roadside infrastructure, preemptively calculates the advisory speed limits and transmits them to the AV via V2C communication. The traffic control center calculates the optimal advisory speed limits for the traffic situation and determines whether to provide them to the AVs. An automated bus in the field that receives these data slows down based on the upper speed limit.



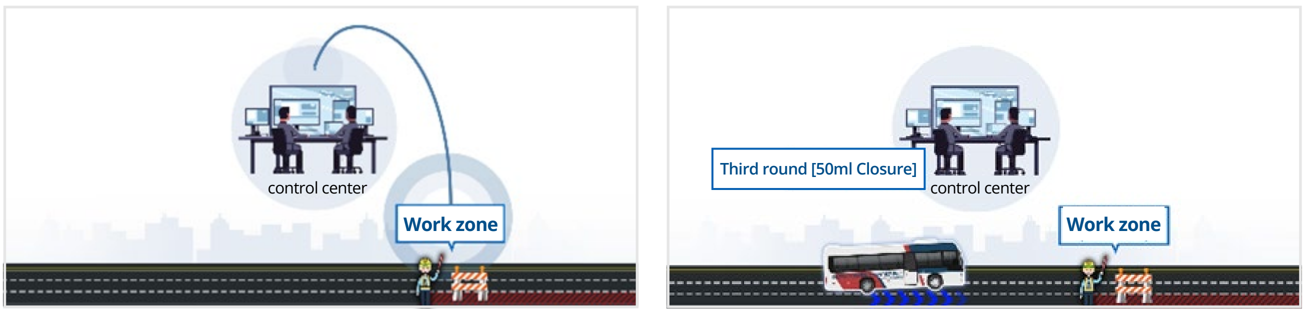
Monitoring traffic conditions(congestion) before speed control of automated bus

Monitoring traffic conditions(congestion) after speed control of automated bus

Figure 6. Conceptual diagram of support services for driving speed to determine traffic conditions. Deceleration.

Figure 7 shows the service required when a specific lane or section the AV is scheduled to enter is closed because of road construction. The traffic control center electronically maps the construction data (location and length of closed lanes or sections) obtained from the road construction agency precisely and provides accurate path information messages to the AV via V2C communication.

In a general scenario in which such services are not available, when an AV approaches a road construction section, it must rapidly decelerate or change lanes near the starting point of the construction, which may pose a risk of collision with vehicles behind or around it. Therefore, lane-change assistance services based on road construction data provided by the traffic control center in advance can enhance safe automated driving.



Provision of road construction data by the traffic control center

Provision of lane change assist data by the traffic control center

Figure 7. Concept diagram of lane-change assistance services in response to road conditions Road construction section/ Lane 3 (50 m) closed/ Road construction section.

Sharing/Integration of Mobility Services

Current status of Mobility Services

The Fourth Industrial Revolution has ushered in a new era of "mobility" in which ICT and innovative technologies converge in the transportation field. This has led to the spread of differentiated user-centered mobility services that are configured from the perspective of consumers, rather than from the perspective of suppliers(e.g., by applying uniform routes and dispatch times). With the emergence of user-centered door-to-door seamless transport services, the introduction of personalized and integrated MaaS, which utilizes various shared means of transportation in conjunction with existing mobility(buses and subways) provided mainly by public transportation and private vehicles, is accelerating.

South Korea's goal is the drastic improvement of existing institutions and infrastructure that block the emergence of creative and diverse mobility services from service users' perspectives. By 2035, all modes of mobility will be linked, including public transportation, railways, micro-mobility, shared vehicles, and taxis, and MaaS will be implemented on a nationwide basis to enable movement within 2-hour zones across the country.

However, the MaaS services that have been previously promoted have not yet been properly activated and established due to various technical and policy limitations, including limitations of data linkage and sharing of diverse public and private mobility means, limitations of the main components and features of MaaS platforms, lack of MaaS governance through a forum for public and private cooperation to activate MaaS services and industry, lack of relevant laws and systems to support MaaS activation, and limitations of sustainable MaaS business models.

Main components and prerequisites of MaaS

Establishment of multimodal/ intermodal data linkage and sharing system

In South Korea, private MaaS platforms and transport service operators collect and store various data, including service vehicle location, operation status, usage history, and payment information, on their own platforms. To improve user mobility and accessibility to transportation through MaaS and create various mobility businesses, access to better information and the systematic use of multiple transportation services should be enabled through efficient data sharing between existing and new mobility services. However, data linkages between different platforms face practical limitations due to the lack of basic principles and standardized data specifications for data sharing, in addition to conflicts of interest between operators.

In overseas cases, including Finland and Switzerland, the legal basis for the mandatory linking of essential public transportation data through standard APIs has been established, enabling them to link with private mobility services. The OECD International Transport Forum mentions the need to recognize mobility data as part of infrastructure and make it the subject of sharing, reporting, and management to realize user-centered MaaS (ITF 2023).

However, in South Korea, there are still practical limitations, including security issues related to linking and sharing public transportation data, data reliability issues, and delayed processing due to increased usage. These limitations are likely to be exacerbated in the near future as new mobility services proliferate, and the complexity and costs associated with data linkage and sharing increase.

Accordingly, to implement the basic functions(searches for multimodal/intermodal means of transportation/optimal routes, reservations, payments for transportation, etc.) and additional features(services connected to other fields and local communities) of MaaS, a data linkage and sharing system for multimodal mobility that acts as a bridge connecting user and operator data is required. Therefore, it is necessary to build an on-demand data relay and linkage platform. In addition, it is critical to ensure protocol and data interoperability through the standardization of multimodal and intermodal mobility data.

Basic functions of integrated mobility as a service (MaaS) platform and establishment of its guidelines

MaaS platforms developed and operated by numerous public and private organizations in South Korea have utilized the platform operators' own technology and solutions for the main components and functions(e.g., multimodal connection, provision of integrated multimodal/intermodal routing, integrated payment, and settlement) of MaaS services. However, because basic guidelines for the development of service functions and platform components and functions to be implemented depending on the level of MaaS(Levels 0–4) have not yet been established or standardized, platform services have been developed competitively using unstructured technologies.

Accordingly, the essential functions, components, and system environments of platforms required to achieve the user and social goals sought through MaaS differ significantly between platforms. Many platforms may lack key features, including data integration/linkage, provision of integrated multimodal/intermodal routing, and integrated fare payment, or may not provide proper service functions.

Table 5 *Status of MaaS in South Korea.*

Classification	R&D		Smart City Challenge project			Public projects		
	Jeju	Daegu	Incheon	Bucheon, Gyeonggi -do	Gangneung, Gangwon -do	Sejong City	Gyeonggi -do	Metropolitan Transport Commission
Data integration/ linkage	X	O	X	X	X	X	X	O
Integrated platform	O	O	X	O	O	O	O	O
In-app operation	O	O	O	X	X	X	X	X
Integrated multimodal/ intermodal routing	X	O	X	X	X	O	X	O
Integrated payment and settlement	O	O	O	X	X	O	X	O
Integrated fare system	X	X	X	X	X	X	X	X
Park-and-ride service	X	O	X	O	X	O	O	O
Connection with private transportation	Demand responsive transit (DRT), rented vehicles, taxis, bicycles	DRT, car-sharing, personal mobility (PM), parking	PM	Car-sharing, PM, parking	DRT, EVs, PM	DRT, PM Avs, parking, car-sharing	DRT, PM	-

Meanwhile, looking into overseas cases of public sector-led projects, including Germany's *Qixxit* and Singapore's *B-Line*, standard platforms have been built by the public sector, and plans have been made for private operators to connect with the platforms. In addition, private sector-led service providers, including Finland's Whim, Germany's Richnow, and Sweden's Fluidtime, have established their own standard platforms and are now operating them through partnerships and agreements with private companies to expand to other regions.

As such, in a context where various levels of MaaS are provided by the public and private sectors, it is necessary to establish the basic functions and components of the domestic MaaS platform as well as guidelines that present the requirements for those components. This requires the creation of a foundation for providing and disseminating MaaS services above a certain level to citizens.

Establishment and operation of an MaaS governance system

MaaS involves a range of stakeholders, including service users, mobility providers, service platforms, system providers, and various public and private organizations related to the MaaS industry. In addition, real-time data on various means of transportation, including new shared mobility services (e.g., personal mobility(PM) and car sharing) and existing means of transportation(taxis, buses, subways, and railroads), should be linked and shared on an integrated operation platform. It is also necessary to establish integrated reservation and payment functions for multimodal/intermodal mobility services as well as an integrated fare system.

Therefore, to provide seamless MaaS services, vitalize related industries, and promote the introduction and expansion of MaaS services by related stakeholders, a governance system for public-private partnerships must be established in which the public and private sectors can work together. Based on this, cooperation can be promoted by coordinating various issues, including data standards and service operation policy consultations, and resolving business concerns or conflicts that may arise.

In Europe, the MaaS Alliance was established and operated by the EU, public transit agencies, and academia to introduce and vitalize MaaS services. Transport operators, MaaS service providers, public institutions, and users participate and cooperate in MaaS market expansion and service scalability. The MaaS Alliance includes three working groups: Governance & Business Models, Users & Rules, and Technology & Standards.

Similar to the European cases above, to develop the MaaS industry in South Korea, a governance system should be established that creates a sectional alliance involving the government, industry, academia, and research institutes. Service scalability and diversification should be supported by improving laws and systems. To this end, the alliance should help form improvement plans for laws and systems in cooperation with the government; it should also help implement mobility policy measures and provide administrative support between the government, local governments, and industry to resolve constraints in service operations.

In addition, internal and external personnel should be trained and reinforced to equip the central and local government officials who operate MaaS services with expertise. Start-ups should be supported by providing field-specific training programs, including data and service (solution) technology, to service providers(e.g., prospective business participants and start-up companies), and an environment for acquiring MaaS knowledge should be created. Further, it is necessary to establish the role and direction of governance in activating MaaS services, including overseas business support for business expansion.

Enactment and revision of laws and institutions to support the activation of integrated mobility as a service(MaaS)

With the recent revision of the Passenger Transport Service Act(April 8, 2021), transportation business based on platforms has been institutionalized. The legislative act on Mobility Innovation and Vitalization Support was passed at the plenary session of the National Assembly and went into effect in October 2023. Thus, through the enactment and revision of mobility-related laws, an institutional foundation has been established to support the introduction and diffusion of mobility services from a consumer perspective, combining innovative technologies, including information and communication technology(ICT) in the transportation field, as well as private sector-led innovative growth.

In particular, the mobility-specific regulatory sandbox system, which is managed by the Ministry of Land, Infrastructure, and Transport(MOLIT), can simplify the existing procedures and shorten the review period compared to the existing system, in which the Ministry of Science and ICT(MSIT) receives applications from business operators and goes through a mandatory consultation process(within 30 days) with MOLIT. Therefore, it seems encouraging that mobility-related business operators can begin new businesses(e.g., automated shuttles operating late at night and cargo transport using PM) utilizing the system that was implemented in October 2023.

However, additional laws and institutions related to mobility are needed to continue promoting the MaaS industry. In particular, to connect the various means required to provide MaaS services, there is a need to review the laws applicable to each mode of transportation and adjust the service provisions and policies, including the Personal Mobility Device Act, Passenger Transport Service Act, Road Traffic Act, Act on the Promotion of and Support for Commercialization of Autonomous Vehicles.

In addition, when developing MaaS service platforms and linking and integrating data, the following laws, including three data-related laws (the Personal Information Protection Act, Act on Promotion of Information And Communications Network Utilization and Information Protection, and Credit Information Use and Protection Act), should be considered: Framework Act on Intelligent Informatization, Software Promotion Act, Act on the Protection of Information and Communications Infrastructure, and Act on the Protection and Use of Location Information. In addition, laws and systems related to various fields, including information and communication, security, and finance, need to be revised or replaced with new laws.

Looking into overseas cases, in the USA, financial support is offered from the central government's budget to businesses, including MOD[1] and IMI[2], in accordance with a new public transportation law that defines MaaS services as a new industry. Finland has revised its regulations on competition and data openness among mobility service operators through the Passenger Transport Services Act to promote free competition in the MaaS market. Australia implements various policies, financial support, and laws, such as providing subsidies for existing businesses and reducing taxi license fees, to alleviate the conflict between new platform-based transportation businesses and the existing taxi industry. France provides terms and conditions for operating shared services through the Mobility Orientation Law, which requires relevant operators to provide data. Japan has laid the foundation for technical standardization through a law on data linkage, which mandates a standard data format and application specifications for transportation operators.

As these examples show, to promote the new MaaS industry, active support is needed, including the enactment of a new law and/or the revision of existing laws covering the policy, financial, and technical domains.

1 Mobility On Demnad: A regulatory sandbox program

2 Integrated Mobility Innovation: MoD, public transportation automation, and integrated payment system projects

Sustainable MaaS business model development

To create sustainable MaaS businesses, there is an urgent need to develop other fields and community-connected services beyond the scope of mobility. Evolution of MaaS business models can ensure its status as a high value-added industry, by focusing on the technical, industrial, economic, social, and cultural values of MaaS services; cooperation with diverse mobility service operators and other industry operators; and mobility-based big data utilization and trading. For example, Hensher et al.(2022) have suggested that the next generation of MaaS will be Mobility as a Feature(MaaF). MaaF is a concept that not only connects transportation services through a digital platform but also combines them with a business model to pursue both social sustainability and economic value creation. The business model integrates corporate social responsibility and sustainability, providing a variety of transportation services. As such, it seems that social integration, which is Level 4 of MaaS services, can be achieved through connections with various other fields as well as mobility.

Germany's MaaS model Qixxit provides not only transportation services through connections with public transportation and other means but also booking and payment services for libraries, shopping, and restaurants. This is accomplished through collaboration with companies, such as Waymate and Allryder, to provide other services. In China, *Suishenxing*(随申行), a MaaS service launched in Shanghai in 2022, aims to prevent traffic congestion while achieving eco-friendly transportation and a low-carbon environment by suppressing the use of private passenger cars through connection with public transportation and other means. Residents can gain green credit when using the service; to increase their participation in the green credit initiative, various business models have been developed and promoted, including public transportation discount coupons, public interest activities including tree-planting campaigns, and the use of green credits at local shops.

Therefore, to develop sustainable business models for MaaS services in South Korea, services beyond mobility should be scaled and developed, including in-platform advertising, revenue generation through mobility data transactions, combination with OTT and streaming services, connection of transportation with leisure and travel accommodations, and services connected to education and medical care.

5. Conclusion

In summary, South Korea is developing electrification-related technologies for both vehicles and charging infrastructure. South Korea's carbon neutrality scenarios include Plan A, which converts 97% of all cars into EVs by 2050, and Plan B, which converts 85% of all cars into EVs by 2050. The National Basic Plan for Carbon Neutrality and Green Growth set a goal of supplying 4.2 million BEVs and 0.3 million FCEVs by 2030. Therefore, considering the policy goals announced by the South Korean government, electrification of road transportation is expected to progress rapidly.

In terms of mobility automation, South Korea seeks to implement autonomous-driving-based mobility services in the daily lives of its citizens by commercializing fully autonomous driving(Level 4) by 2027. However, automated driving technology still needs to address the failure of sensors due to dynamic factors, including objects outside the detectable spatial range, blind spots, differences between day and night, and bad weather. These challenges have prevented autonomous driving from moving beyond Level 3. In response, South Korea is focusing on developing connected and automated driving services using C-ITS technology and V2V, V2I, and V2C communication.

In terms of mobility sharing and integration, various MaaS platforms are being developed and operated by numerous public and private organizations in South Korea. However, because basic guidelines for the development of service functions or platform components and functions for MaaS levels(0–4) have not yet been established, different public and private actors have each followed their own paths. Hence, laws and guidelines for MaaS development and governance systems must be established at the national level.

For a successful mobility transformation, industries, technologies, social safety nets, and employment must work together in the transformation ecosystem to form a single market, which then exerts a positive impact on other components in a virtuous cycle. In this virtuous cycle, electrification, decarbonization, automation, and sharing/integration must be achieved simultaneously within a single framework.

Legal and Institutional Improvements in Germany

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Introduction

To facilitate transport transition, a wide variety of stakeholders for all modes of transport must work together in a coordinated manner. Legal certainty also plays an important role in this process.

This chapter provides an overview of important topics related to the transport transition, its legal framework, and relevant institutions; it also identifies important challenges related to these issues. First, it discusses the influence of international, European, and national climate legislation on Germany's transportation sector. Subsequently, the topics of electric mobility in motorized private transport, legal innovations concerning autonomous and connected driving, smart mobility and mobility data, and the concept of mobility laws are examined.

Impact of climate protection legislation on the transport sector

Climate legislation at the international, supranational (European), and national levels provides the necessary legal framework for the successful global transformation of all sectors, including the transport sector. Only through the development of accountability and legally binding targets and processes can the measures necessary to reduce emissions be verified and enforced. Depending on the level of legislation, different institutions operate by using the different legal instruments at their disposal.

International Climate protection law and its legally binding effect

The United Nations Framework Convention on Climate Change(UNFCCC), which took effect in 1994, is one of the three Rio Conventions adopted at the first Rio Earth Summit in 1992. For the first time, the international community recognized global climate change as a serious problem and committed to action. With 198 Parties, the Convention has near-universal membership. The UNFCCC Secretariat, based in Bonn, Germany, is a United Nations entity tasked with supporting the global response to the threat of climate change.[1] The signatories meet annually for the Conference of the Parties(COP). In 1997, the parties concluded the Kyoto Protocol, which introduced the first legally binding targets for industrialized countries to reduce emissions. The Protocol envisaged a top-down scheme with fixed national climate-protection contributions.

In 2016,[2] the Paris Agreement(PA) entered into force as a follow-up agreement to the Kyoto Protocol, opening a new chapter on international climate protection law. More than 190 countries agreed to the ambitious climate protection target to hold the increase in the global average temperature to well below 2°C above pre-industrial levels.[3]
German CO_2 emissions, including those from the transport sector, must decline drastically if the Paris targets are to be met. To meet the more ambitious 1.5°C target, transport emissions must fall by 53% by 2030 compared to 1990 levels. To meet a 2°C target, Germany would need to reduce its transport emissions by 44% by 2030.[4]

The PA replaced the top-down scheme from the Kyoto Protocol with a bottom-up process with voluntary national commitments.[5]
The Agreement binds the parties through a hybrid structure featuring

1 https://unfccc.int/about-us/about-the-secretariat?gclid=CjwKCAiA3aeqBhBzEiwAxFiOBrViy1ORmV7oVnUvW7QmNwiLJ8GYD9hLcv0mBYWFEQqb4EnhKMN2HxoCWdsQAvD_BwE

2 Both the Republic of Korea and Germany signed the Paris Agreement on 22 April 2016.

3 Art. 2 I b) Paris Agreement, https://unfccc.int/files/essential_background/convention/application/pdf/english_paris_agreement.pdf.

4 Agora Verkehrswende (2019): En route to Paris? Implications of the Paris Agreement for the German transport sector

5 NVwZ 2017, 1574.

political enforcement control by a global environmental public combined with the authority of national courts, which can be seen as decentralized judicial control.[6] Parts of the PA are, therefore, fully specified provisions that precisely designate the subject and object of the obligation; this does not leave compliance to the discretion of the contracting parties. The most important provision qualified in this way was the mandatory participation of all Parties in the “bottom-up” process of developing, transmitting, and implementing nationally determined contributions(NDC) (Article 4 II PA). The firm legal quality is captured in the use of the indicative mood in the treaty text, as opposed to "shall" requirements for Parties, such as in Art. 4 IV PA.[7] In this context, the International Transport Forum, an intergovernmental organization with 59 member countries, reviews the updated NDC submissions every five years to assess how ambitious their transport commitments are.[8]

European Union and EU climate legislation

Germany is one of the six founding countries of the European Union.[9] For member states, EU law has far-reaching effects on national legal areas.

EU Law and Institutions

The European Union(EU) is an economic and political union of 27 member states. This unique legal and political system is supported by the member states and the EU institutions. The European Commission is solely responsible for drafting proposals for new European legislation and implementing the decisions of the directly elected European Parliament and the Council of the EU, which sets the union’s general policy objectives and priorities.

Similar to the way sovereign states distinguish between their constitutional laws and other legislation, the EU law differentiates between primary and secondary laws.[10]
The Treaty on European Union(TEU) and the Treaty on the Functioning of the European Union(TFEU) comprise EU primary law; the two treaties set out the principles and objectives of the EU, as well as the scope for action in its policy areas. The aims set out in the EU treaties are achieved through several types of legal acts.[11]

6 ZUR 2021, 131

7 NVwZ 2017, 1574

8 ITF, Transport CO2 and the Paris Climate Agreement; Reviewing the Impact of Nationally.
Determined Contributions, p. 7, https://www.itf-oecd.org/sites/default/files/docs/transport-co2-paris-climate-agreement-ndcs.pdf.

9 In 1951, Belgium, Germany, France, Italy, Luxembourg and the Netherlands founded the European Coal and Steel Community. It was the first predecessor organisation of the European Union.

10 Pechstein/Nowak/Häde, Frankfurter Kommentar EUV/GRC/AEUV/Häde, 1. Aufl.
2017, AEUV Art. 1 Rn. 4.

11 https://european-union.europa.eu/institutions-law-budget/law/types-legislation_en.

A "regulation" is a binding legislative act and must be applied in its entirety across the EU. In addition, there is the possibility of adopting an EU legal act as of a "directive," which sets out a goal that EU countries must achieve. However, it is the responsibility of individual countries to devise their own national laws on how to achieve these goals. Although EU law holds precedence, it does not nullify the national laws of member states. However, national law is not applicable as long as EU law is relevant(the principle of the primacy of EU law). European legal acts often represent the lowest common denominator among member states. Nevertheless, EU member states are permitted to exceed the minimum legal requirements of EU legislation. In cooperation with the courts of member states, the European Court of Justice(ECJ) ensures the uniform application and interpretation of EU law.

European Green Deal

The European Green Deal, which was signed by the EU and its member states in 2015, is a package of policy initiatives to set the EU on the path to green transition. It was launched in December 2019 as part of the implementation of the PA.

In July 2021, the European Commission proposed several legislative revisions to the Green Deal under the "Fit for 55" policy package. These measures enshrine the climate ambitions of the Green Deal into law[12] by introducing the European Climate Law. The legislative package also included revisions to the EU Emissions Trading System(ETS) Directive[13] and Effort Sharing Regulation(ESR).[14]

EU climate legislation constitutes an important lever to facilitate the EU-wide decarbonization of the transport sector.

· ***European Climate Law***

The European Climate Law[15] entered into force in July 2021 and set out the EU's target to reduce greenhouse gas(GHG) emissions by at least 55% by 2030 compared to 1990 levels. It includes a legal objective for the EU and its member states to reach climate neutrality by 2050. It is a European regulation and includes a mechanism for keeping all member states on track, with regular reporting of progress and tools to catch up in case any country falls behind.

12 https://www.consilium.europa.eu/en/policies/green-deal/

13 Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a system for greenhouse gas emission allowance trading within the Union and amending Council Directive 96/61/EC

14 Regulation(EU) 2023/857 of the European Parliament and of the Council of 19 April 2023 amending Regulation(EU) 2018/842 on binding annual greenhouse gas emission reductions by member states from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement, and Regulation(EU) 2018/1999.

15 REGULATION(EU) 2021/1119 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations(EC) No 401/2009 and (EU) 2018/1999, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32021R1119.

· ***Effort Sharing Regulation***

The ESR establishes legally binding emission reduction targets for each EU member state based on their economic performance in the transport, buildings, agriculture, and waste sectors. It initially affected all sectors not covered by the EU Emission Trading System(see 2.2.2.3), which contribute 60% of total EU emissions. The country targets range from -10%(Bulgaria) to -50%(e.g. Germany).[16] The ESR legislation, first adopted in 2018, was revised in 2023 to deliver a 40% reduction in emissions covered by the ESR by 2030 compared with 2005. Having considered the intended use of flexibility options, if the Commission determines in its annual assessment that a member state is not making sufficient progress in meeting its commitments, the member state shall submit a corrective action plan to the Commission within three months.

From 2013–2020, across the EU, the overall emissions ceilings for the transport and buildings sectors up to 2020 were met within the European effort-sharing mechanism, because several member states outperformed their climate targets. By contrast, Germany failed to meet the binding EU targets in the transport, buildings, industry, and agriculture sectors. Germany had to buy more than 11 million annual emission allowances from other member states(Bulgaria, Czechia, and Hungary) and pay several million euros in 2022.[17]

· ***Emission Trading System I and II(ETS)***

The ETS is the EU's key tool for reducing GHG emissions.[18] The legal framework of the system is outlined in the ETS directive. Approximately 40% of all GHG emissions generated in the EU have been covered since the 2005 EU-ETS I, which includes electricity, heat generation, energy-intensive industry, and air traffic in the European economic area. The ETS requires EU producers to buy allowances for GHG emissions. One allowance provides the right to emit one ton of CO2 (carbon dioxide equivalent). The carbon price in the European market reached €100/t of CO2 for the first time in spring 2022.[19] The system works on the "cap and trade" ' principle. A cap is a limit set on the total amount of GHG emitted by the producers covered by the system. The cap is reduced annually in line with the EU's climate target. Since 2005, the EU ETS has helped bring down emissions from power plants and industry by 37%.[20] The revenues are fed into national budgets and various EU funds.

A new ETS(EU-ETS II) will be established in 2025 as a separate self-standing trading system. Entities that release GHG through fuel combustion in the buildings and road transport sectors must trade

16 Annex I, Regulation(EU) 2023/857 of the European Parliament and of the Council of 19 April 2023 amending Regulation(EU) 2018/842 on binding annual greenhouse gas emission reductions by member states from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement, and Regulation(EU) 2018/1999.

17 https://www.bmwk.de/Redaktion/EN/Pressemitteilungen/2022/10/20221024-germany-acquires-emission-allowances-for-failures-to-meet-climate-targets-between-2013-and-2020.html

18 https://www.consilium.europa.eu/en/infographics/fit-for-55-eu-emissions-trading-system/

19 Current prices see: https://www.statista.com/statistics/1322214/carbon-prices-european-union-emission-trading-scheme/#:~:text=The%20price%20of%20emissions%20allowances,of%20CO%E2%82%82%20in%20February%202023.

20 https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets/what-eu-ets_en

allowances within this ETS. This reform is welcome, as the expansion of emissions trading to other sectors will lead to decarbonization of these sectors, as long as emission prices are implemented.

The emissions cap for EU ETS II will be set beginning in 2026 and decrease over time to reach emission reductions of 43% by 2030 compared to 2005 for the targeted sectors.
Carbon pricing cannot overcome all of the barriers to the deployment of low- and zero-emission solutions in the road transport sector. Therefore, the ESR will remain applicable. This means that the transport sector will be decarbonized by both the ETS II instrument and national policies based on the ESR. Additionally, some member states have already established a national ETS for transport and buildings(e.g., Germany, see Section 2.3.2) that will have to be coordinated with the new EU ETS II. In this regard, legal amendments must be made to the Fuel Emissions Trading Act(Brennstoffemissionshandelsgesetz, BEHG[21]).
Carbon prices set out by the ETS across all sectors are also further impacted by fossil fuel subsidies and other harmful fiscal measures (e.g., energy tax concession for diesel fuel); in Germany, this amounts to €65 billion[22] to maintain firms' competitiveness and avoid increases in the cost of living.[23] However, these harmful policies should be evaluated a balanced manner and gradually eliminated.[24]

· ***Euther relevant EU legislation***
Further relevant EU legislation concerns e.g. renewable energy, emission standards for vehicles and requirements for the aviation and shipping sector. This is not an exhaustive list of relevant legal acts.
Amendments to Directive(EU) 2018/2001 on the promotion of the use of energy from renewable sources(Renewable Energy Directive, referred to as RED III)[25] propose decarbonization targets for EU member states across the transport, industrial, buildings, heating, and cooling sectors. The amendments expand the use of renewable fuels of nonbiological origin, such as green hydrogen.

Regulation(EU) 2023/851[26] sets standards for reducing CO2 emissions from new cars and vans. The emissions of new passenger cars and vans registered in the EU shall be reduced by 55% and 50%, respectively, by 2030. By 2035, the emissions shall be reduced by 100% for both new passenger cars and new light commercial vehicles.

21 Fuel Emissions Trading Act of 12 December 2019(Federal Law Gazette I p. 2728), which was last amended by Article 7 of the Act of 22 December 2023 (Federal Law Gazette 2023 I No. 412)

22 Burger, A. and W. Bretschneider(2021), Environmentally harmful subsidies in Germany.

23 OECD Economic Surveys: Germany 2023, Key policy instruments for a net-zero economy, https://www.oecd-ilibrary.org/economics/oecd-economic-surveys-germany-2023_9642a3f5-en

24 OECD Economic Surveys: Germany 2023, Key policy instruments for a net-zero economy, https://www.oecd-ilibrary.org/economics/oecd-economic-surveys-germany-2023_9642a3f5-en

25 Directive(EU) 2023/2413 of the European Parliament and of the Council of 18 October 2023 amending Directive(EU) 2018/2001, Regulation(EU) 2018/1999 and Directive 98/70/EC as regards the promotion of energy from renewable sources, and repealing Council Directive(EU) 2015/652, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32023L2413

26 Regulation(EU) 2023/851 of the European Parliament and of the Council of 19 April 2023 amending Regulation(EU) 2019/631 as regards strengthening the CO2 emission performance standards for new passenger cars and new light commercial vehicles in line with the Union's increased climate ambition, https://eur-lex.europa.eu/eli/reg/2023/851

In the spring of 2023, the European Commission submitted a proposal to revise the CO_2 emission standards for heavy-duty vehicles.[27] The legislative process is still ongoing. Furthermore, the ReFuelEU Aviation[28] and FuelEU Maritime[29] regulations were adopted to boost the uptake of renewable and low-carbon fuels in these transport modes.

· ***Current developments***

In May 2023, the EU and the Republic of Korea launched a Green Partnership. Both sides confirmed their willingness to increase cooperation under the UNFCCC, Paris Agreement, and Convention. Both sides recognize their respective green deals and the importance of carbon pricing, including emission trading systems, in achieving sustainable growth, jobs, and competitiveness, along with net-zero, nature-positive, circular, and resource-efficient economies by 2050. Furthermore, both sides intend to enhance cooperation on green mobility and technologies such as batteries.[30]

German climate protection legislation

In addition to the EU targets, Germany has set its own climate protection targets to guide national legislation.

National climate legislation

The German Federal Climate Protection Act(Klimaschutzgesetz-KSG)[31], which mandates GHG neutrality by 2050, came into force in December 2018. It forms a legislative framework and imposes binding obligations on public entities. Its main purpose, according to Section 1, is to "ensure the fulfillment of national climate protection targets and compliance with European targets," which are in turn based on the PA(see above)[32].

However, in the view of the Federal Constitutional Court, the Climate Protection Act was partly unconstitutional. Its regulations on national climate protection targets and the annual emission levels permitted up to 2030 were deemed to be incompatible with fundamental rights, as sufficient requirements for further emission reductions from 2031 were missing. According to the Court, the regulations irreversibly postponed high emission reduction burdens to periods after 2030.

27 COM, https://climate.ec.europa.eu/system/files/2023-02/policy_transport_hdv_20230214_proposal_en_0.pdf

28 Regulation(EU) 2023/2405 of the European Parliament and of the Council of 18 October 2023 on ensuring a level playing field for sustainable air transport(ReFuelEU Aviation), https://eur-lex.europa.eu/eli/reg/2023/2405

29 Regulation(EU) 2023/1805 of the European Parliament and of the Council of 13 September 2023 on the use of renewable and low-carbon fuels in maritime transport, and amending Directive 2009/16/EC, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32023R1805

30 https://www.consilium.europa.eu/en/press/press-releases/2023/05/22/european-union-republic-of-korea-green-partnership/

31 Federal Climate Protection Act of December 12, 2019 (Federal Law Gazette I p. 2513), which was amended by Article 1 of the Act of August 18, 2021(Federal Law Gazette I p. 3905)

32 BerlKommEnR/Ehrmann, 5th ed. 2022, TEHG § 1 marginal no. 21.

33 Article 20a GG: Mindful also of its responsibility towards future generations, the state shall protect the natural foundations of life and animals by legislation and, in accordance with law and justice, by executive and judicial action, all within the framework of the constitutional order.

34 Current version of November 2023.

The German Constitution(Grundgesetz, GG) stipulates that GHG emissions must be reduced. Achieving the Paris target of limiting the increase of global average temperature to 2°C or, if possible, 1.5°C above the pre-industrial level would constitute the realization of Article 20a.[33] The immediate consequence of the decision was an amendment to the act calling for GHG to be reduced by at least 65% rather than 55% by 2030. The year 2040 was added as a new interim target for a reduction of 88%. Finally, climate neutrality is to be achieved five years earlier(2045 as compared to the initial target of 2050).

One distinctive feature of the act in its current version[34] is that it contains annual emission quantities for individual sectors(energy, industry, transport, buildings, agriculture, waste management, and miscellaneous) specified exactly in millions of metric tons of CO2 equivalent for the individual years from 2020 to 2030 (see Section 4 in conjunction with Annexes 1 and 2 of the act). In the transport sector, the annual emission volume stipulated in the KSG was exceeded by 2 and 9 million tons in 2021 and 2022, respectively. The Federal Ministry for Digital and Transport(BMDV[35]) therefore submitted proposals for additional climate protection measures in the transport sector.

In June 2023, the German government coalition, which consisted of socialists(SPD), greens(Die Grünen), and liberals(FDP), launched a new version of the KSG. The draft stipulates that in the future, a multiyear and cross-sectoral overall accounting of emissions will be the decisive factor for further measures. This means that the focus will be on whether GHG emissions are reduced overall, regardless of the sector in which GHG are produced. However, the climate targets remain unchanged.

According to the Federal Government's own statement, the current draft of the Climate Action Program 2023 will not achieve the climate targets in total for the years 2021–2030, across sectors, or for individual sectors (e.g., transport)[36].

Furthermore, the 2023 climate protection program is not suitable for complying with the ESR goals (see Section 2.2.2). If Germany misses the targets, it will have to pay penalties and purchase emission allowances from other EU member states, amounting to several billion Euros[37].

If amendments to the KSG are passed as proposed by the current

35 The Ministry is headed by the Minister(currently Volker Wissing,(FDP). He is appointed by the Federal Government.

36 German Council of Experts on Climate Change, Statement on the draft of the Climate Protection Program 2023, In accordance with Section 12(3) No. 3 of the Federal Climate Protection Act, 2023, p. 23, German report: https://expertenrat-klima.de/content/uploads/2023/09/ERK2023_Stellungnahme-zum-Entwurf-des-Klimaschutzprogramms-2023.pdf, The Expert Council on Climate Issues is an independent panel consisting of five experts from various disciplines. It was established in September 2020 and is mandated by Sections 11 and 12 of the Federal Climate Change Act(KSG).

37 EURACTIV, Costly gap: Germany to fall significantly short of EU climate targets, 2023, https://www.euractiv.com/section/energy-environment/news/costly-gap-germany-to-fall-significantly-short-of-eu-climate-targets/?_ga=2.216910495.860992198.1699371569-724419037.1699008856.

government, it can be assumed that the Federal Constitutional Court will review its constitutionality.

National Emission Trading

In December 2019, the BEHG[38] was passed, mandating national emissions trading for the heat and road transport sector, which began in 2021. Under the BEHG, a fuel is deemed to have been placed on the market if a tax liability arises for it according to the Energy Tax Act.[39]
The German Emissions Trading Authority of the Federal Environment Agency was appointed to enforce this act.

38 Fuel Emissions Trading Act of December 12, 2019 (BGBl. I p. 2728), which was last amended by Article 2 of the Act of November 9, 2022(BGBl. I p. 2006)

39 https://www.dehst.de/SharedDocs/Newsletter/DE/2022/2022-11-28-nehs-behg-novelle-zertifikatspreise-behg-novelle.html.

Electro Mobility
– Public stationary charging

To achieve a transition towards sustainable energy use in the transport sector, German strategies and legislation prioritized the increased utilization of renewable energy sources for drive systems. Battery-electric mobility is a key technology for the design of a sustainable transport sector and for achieving climate protection goals. As the electromobility market rises, it will make a tangible contribution to climate protection and the improvement of air quality, especially in cities. Finally, electromobility offers important industrial policy opportunities for Germany as a business location.

The German Federal Government promotes the development of electromobility by setting the necessary framework conditions using a comprehensive package of measures that are continuously evaluated, expanded, and adapted. These include support for research and development, a purchase premium for electric cars,[1] expansion of charging infrastructure, uniform charging standards, procurement targets for the public sector, and privileges for electric car owners (e.g., parking). The successful market ramp-up for electromobility also requires a coordinated and clear legal framework. Regulatory measures for the electromobility sector can be found at European, national, and local levels.[2] Implementation is primarily conducted through cooperative collaboration between government agencies, municipalities, network operators, charging-point operators, and other stakeholders.

Deployment of Infrastructure and competition

A privately available charging infrastructure is the most important condition for the widespread adoption of electric passenger cars. The second most frequent charging location is the workplace. While public charging infrastructure is currently the third most frequent location for charging, electric vehicle owners without garages or parking spaces of their own, who represent a minority of vehicle owners in Germany, are particularly dependent on them[3].

Deployment of public infrastructure in the EU and Germany

As part of the "Fit for 55"-package, the EU's plan for a green transition, the Alternative Fuels Infrastructure Regulation(AFIR) was adopted in

1 As of September 1, 2023, only individuals are eligible to apply and plug-in hybrid vehicles will no longer receive support through the environmental bonus.

2 BMDV, Regulatory landscape for electric mobility, 2022, https://www.now-gmbh.de/wp-content/uploads/2022/09/Regulatory-landscape-for-electric-mobility.pdf

3 https://publica-rest.fraunhofer.de/server/api/core/bitstreams/b33abb5b-f66b-47d4-9986-0d53661cbea2/content

September 2023. It will be fully applicable from April 2024 onwards. This legal act lays down mandatory minimum targets for the deployment of publicly accessible and user-friendly electric recharging infrastructure for light-duty and heavy-duty electric vehicles, Art. 3 and 4 AFIR.

On behalf of the German Federal Ministry for Digital and Transport, the National Centre for Charging Infrastructure(Nationale Leitstelle Ladeinfrastruktur) coordinates and manages activities to expand the public charging infrastructure in Germany.
According to the German government's Charging Infrastructure Master Plan II[4], one million charging points should be available to the public in Germany by 2030[5]. For fast-charging infrastructure on highways ("Deutschlandnetz"), public tenders were held. In Germany, twice the charging capacity required by AFIR has already been installed.[6]

Missing competition in public charging

The Charge Point Operator(CPO) is responsible for the operation of the charging points and their connection to the IT infrastructure. The CPO often owns the charging points. According to the Charging Point Ordinance(Ladesäulenverordnung, LSV)[7], a CPO is a person who, considering legal, economic, and factual circumstances, has a determining influence on the operation of a charging point. During stationary charging, CPOs operate the infrastructure and supply electricity simultaneously.

· ***No Unbundling***

Unlike household electricity customers, charge-point customers in Germany cannot choose their electricity suppliers. The legislature has made the combined offer of infrastructure provision and electricity supply from a single source legally possible by considering the CPO as an "end consumer"(Letztverbraucher) pursuant to Section 3 No. 25, Hs. 2 of the German Energy Industry Act(Energiewirtschaftsgesetz – EnWG).[8] This means that the CPOs are not subject to the strict access and fee regulation of the EnWG; they are not considered electricity suppliers pursuant to Section 3 No. 31a of the EnWG; and they can therefore devote themselves to infrastructure development without any restrictions that they would have otherwise. However, this approach does not foster competition for electricity, which can lead to higher prices.

4 https://nationale-leitstelle.de/wp-content/uploads/2023/05/Masterplan-Ladeinfrastruktur-II-der-Bundesregierung_Englisch_barrierefrei_2023_05_03.pdf.

5 The target of one million charging points by 2030 is technologically outdated. The decisive factor is the charging capacity which is relevant according to the AFIR.

6 BDEW, Elektromobilitätsmonitor, 2023, https://www.bdew.de/media/documents/BDEW_Elektromobilit%C3%A4tsmonitor_2_2023_SmMJoQW.pdf

7 Charging Point Ordinance of March 9, 2016(BGBl. I p. 457), as last amended by Article 1 of the Ordinance of June 17, 2023(BGBl. 2023 I No. 156)

8 Energy Industry Act of July 7, 2005(Federal Law Gazette I p. 1970; 3621), last amended by Article 24 of the Act of October 8, 2023(Federal Law Gazette 2023 I No. 272)

Currently, giving customers the right to choose their own energy supplier when using charging points is optional for the CPO, thus ensuring more effective competition for electricity prices. However, this also increases the complexity of energy market processes, which is why this model is not widely applied by CPOs. Nevertheless, in the near future, CPOs should be obligated to provide access to different energy suppliers so that charge-point clients can choose between them.

· ***Regional monopolies of public charging points***

The operation of public charging points is currently characterized by a monopoly structure in certain German regions, as some CPOs have a dominant market position. In some regions, up to 91% of public charging points are in the hands of a single operator, which restricts price competition[9]. This lack of competition among charging-point operators might have the potential to slow the expansion of electromobility in Germany. It deprives CPOs of the incentive to lower charging prices because their stations face no competition. CPO competition accelerates the expansion of the charging network. With no competition, no further network expansion is required to become the most attractive provider[10].

Competitive and nondiscriminatory access for CPOs to suitable areas is crucial for the emergence or maintenance of competition in the field of publicly accessible charging infrastructure. Away from highways, municipalities decide how areas and surfaces can be used. Therefore, their allocation behavior is particularly significant.
In 2021, the Federal Cartel Office(Bundeskartellamt) called for "greater promotion of the emergence of competitive market structures by means of a legal requirement to award public land."[11] Instead of allocating space through special use permits(Sondernutzungserlaubnis) or concession agreements, municipalities should opt for public tendering on a more regular basis.

Sector coupling

How can the increasing electricity consumption of electric cars be reconciled with the limited capacity of electricity grids? Two provisions of the EnWG[12] that attempt to answer this question are explained in this section. The main challenge with these legal provisions is their implementation. Technical and administrative conditions must be

9 https://www.lichtblick.de/presse/monopolanalyse2022/.

10 EnWZ 2023, 147, 148.

11 EnWZ 2021, 433 (434).

12 Energy Industry Act.

satisfied to enable these processes.

Grid control via electric vehicles

The distribution grid operator is given the opportunity to regulate the energy consumption of electric vehicles charging in private households to maintain secure grid operation(see Section 14).
This can only be controlled as much as is absolutely necessary. A complete shutdown is not permitted. In return, the end consumers are granted a flat-rate discount on the grid fee. These processes require the installation of smart metering systems, which represents a challenge for the responsible metering point operators.

Consideration of electromobility in grid planning

Operators of electricity distribution grids have to draw up a so-called "regional scenario," which forms the common basis for the respective grid expansion plans of the operators in their region(see Section 14 d (3) No. 3 of the EnWG). For integrated planning, suitable assumptions must be made regarding the development of other sectors within the scenarios. Particular attention must be paid to the rapidly advancing electrification in the transport and heating sectors[13].

13 BT-Drucksache 20/1599, https://dserver.bundestag.de/btd/20/015/2001599.pdf, p. 55.

Autonomous and connected driving

Autonomous driving also plays an important role in the mobility transition. Germany sees itself as a pioneer in this area and allowed vehicles with SAE-Level 3[1] in 2017[2]. A few years later, Germany became the first country in the world to create a framework to allow autonomous vehicles with SAE-Level 4. In addition to national laws, European and international legal requirements must also be observed.

National Law

The Autonomous Driving Act came into effect in Germany on July 28, 2021[3], ushering in substantial and comprehensive changes to the German Road Traffic Law(Straßenverkehrsgesetz-StVG)[4]. A key aspect of these changes is the precise criteria for vehicles equipped with autonomous driving functions, aligned with the SAE-Level 4 classification[5]. This legislation now allows for the operation of autonomous vehicles without a physically present driver but only within specified operation areas and under so-called "Technical Supervision."

This refers to a human backup who remotely monitors vehicles and can intervene in critical situations. Consequently, Germany has played a pioneering role in establishing technical prerequisites for the operation of autonomous vehicles and defining the fundamental responsibilities of the parties involved during operation.

Alongside these revisions, a new centralized approval process for autonomous vehicles was introduced, a process overseen by Germany's Federal Motor Transport Authority(Kraftfahrt-Bundesamt-KBA). In addition, the associated implementing ordinance - "Autonomous Vehicle Approval and Operation Ordinance"(Autonome-Fahrzeuge-Genehmigungs-und-Betriebs-Verordnung - AFGBV)[6] - was adopted in 2022. It specifies and supplements the newly introduced regulations in the StVG (Sections 1d to 1l).

Impact on Mobility Transition in Germany

The New Autonomous Driving Act is expected to have a significant impact on public transportation in Germany, with public transportation being one of its primary beneficiaries. The main goal of the legislation was to streamline the introduction of new mobility services including

1 SAE = Society of Automotive Engineers; see all levels: https://www.sae.org/blog/sae-j3016-update.

2 Eighth law amending the StVG, BGBl. Part I, p. 1648.

3 BT-Drs. 19/27439.

4 Road Traffic Act in the version published on March 5, 2003(Federal Law Gazette I p. 310, 919), last amended by Article 16 of the Act of March 2, 2023 (Federal Law Gazette 2023 I No. 56)

5 https://www.sae.org/blog/sae-j3016-update.

6 Autonomous Vehicles Approval and Operation Ordinance of June 24, 2022 (Federal Law Gazette I p. 986), which was amended by Article 10 of the Ordinance of July 20, 2023 (Federal Law Gazette 2023 I No. 199).

autonomous shuttle services, robot taxis, and various modes of public transport.[7] German authorities anticipate that the implementation of this act will lead to improved traffic safety by reducing human error, which is responsible for more than 80% of accidents, through the increased integration of autonomous vehicles on German roads. In addition, policymakers in Germany foresee positive environmental outcomes, such as a reduction in CO_2 emissions, resulting from the greater adoption of autonomous vehicles, which can enhance passenger transportation efficiency.

For example, CO_2 emissions can be minimized by providing passenger transport on an on-demand basis. Furthermore, the introduction of autonomous vehicles implies decreased reliance on private vehicles in rural areas and potentially fewer individual trips. By increasing the frequency of trips, policymakers aim to use autonomous shuttles to enhance connectivity between cities, suburban areas, and rural regions that have historically had inadequate access to public transportation. Offering on-demand public transportation is considerably more cost effective than providing inflexible services with lower demand during off-peak hours. Labor costs can also be reduced by eliminating the need for a driver and having a single technical supervisor oversee multiple vehicles.

Approval process

First, an operating license for a vehicle with autonomous driving functions, in accordance with Section 1e(4) of the StVG, must be available. To secure a license, the vehicle manufacturer must submit an application to the KBA[8], and the vehicle must meet the technical requirements of Section 1e(2) of the StVG. It is also necessary for the manufacturer to submit a declaration in accordance with Section 1f(3) No. 4 of the StVG in the so-called operating manual. In this declaration, the manufacturer makes a binding declaration that the vehicle fulfills the technical requirements.

If the requirements are met, the KBA issues an operating license in accordance with section 1e(4) of the StVG. Vehicles with autonomous driving functions can be used only in defined and approved operational areas. A legal definition of the operating area can be found in Section 1d (2) of the StVG:

7 BT-Drs. 19/27439 S. 15.

8 Section 3 AFGBV in conjunction with Annex 1

"A defined operating area within the meaning of this Act refers to the locally and spatially defined public road area in which a motor vehicle with an autonomous driving function may be operated if the requirements pursuant to Section 1e(1) are met."

The area is defined by the vehicle owner and must include areas dedicated to road traffic that are accessible to the public[9].
The application for the approval of the operating area must be submitted to the local state transport authority. Depending on the type of road, the responsibility may arise from federal or state laws.
The application must include the following aspects in accordance with Section 8 of the AFGBV. The area in the application must be displayed on a map, and the operating purpose and conditions must be specifically described. In addition, the manufacturer must provide proof that autonomous driving functions can be deactivated at any time in the operating area and that control over driving maneuvers can be released at any time[10].

The operating area must also be suitable, within the meaning of Section 9(2) of the AFGBV. If the local state transport authority determines that the motor vehicle can independently perform a driving task in a specified area, the area will be deemed suitable. If the motor vehicle is not technically capable of fulfilling traffic regulations in an area owing to complexity or necessary interactions with other road users, the respective operating area is not considered suitable. In addition, the road infrastructure along the relevant route must meet the technical requirements for the operation of motor vehicles with autonomous driving functions.

Technical Supervision

From the control center, the technical supervisor oversees the system of the autonomous vehicle, occupants, and other road users. A legal definition of Technical Supervision is provided in Section 1d(3) of the StVG. The technical supervisor is a human operator who must be able to deactivate a motor vehicle at any time during operation[11] and to approve driving maneuvers.[12]

The range of tasks performed by a technical supervisor is described in Section 1f(2) of the StVG. An alternative driving maneuver proposed by

9 BT-Drs. 19/27439, 20.

10 Section 8(1) No. 2 AFGBV.

11 Section 1e(2) No. 8 StVG.

12 Section 1e(2) No. 4 and(3) StVG.

13 Section 14(3) sentence 1 AFGBV in conjunction with Annex 1 no. 4 AFGBV.

the vehicle must be evaluated in accordance with Section 1e, Para. 2 No. 4, Para. 3 of the StVG, and, if necessary, approved. Section 1e (3) of the StVG provides an exception. In the case of other impairments that result in the vehicle being unable to perform the driving task independently, driving maneuvers can be specified by the technical supervisor. This makes it possible to resolve atypical situations that would otherwise be handled by human drivers and other road users through cooperative actions.

In the event of a technical defect, the driving task must be performed manually by technical supervisor until the defect is rectified[13]. If road safety is at risk, the vehicle must be immediately removed from the road and inspections must be carried out[14]. If the vehicle is in a condition that minimizes risk, Technical Supervision must immediately contact the occupants and take necessary measures to ensure road safety.

Permanent monitoring of the vehicle by Technical Supervision is not required; however, the vehicle must be ready to deactivate autonomous driving functions immediately at any time[15]. Therefore, monitoring is limited to evidence checks[16].

Sand box for autonomous driving functions

Section 1i(1) of the StVG introduced the possibility of testing autonomous driving functions in motor vehicles. This new experimentation clause was intended to make it easier for manufacturers to test new autonomous driving functions. The requirements for granting test permits are specified in Section 16(3) of the AFBGV. After an operating license is granted, modifications must be made to the vehicle to equip it with automated or autonomous driving functions.
Furthermore, the owner must submit a development concept that adequately describes the driving functions to be tested, compliance with the current state of the art(Section 1e (2) of the StVG), and the permanent monitoring of operation. Furthermore, non-personal data and events related to technological progress in the development stage must be included.

The autonomous vehicle system must also be able to be deactivated at any time and overridden onsite. Test approval must be limited in time

14 Section 14(3) sentences 4 and 5 AFGBV.

15 Section 1e (2) No. 8 StVG.

16 König, in: Hentschel/König/Dauer, § 1f Rn. 9; Gatzke, NZV 2022, 62(66).

in accordance with Section 16(2) of the AFGBV and may not normally exceed four years. It can be extended for a further two years in each case if the conditions for granting approval continue to apply. The validity area is limited to a specific test vehicle. In contrast to the approval for regular operation, the operating area is not limited to a "defined operating area" from the outset by the wording of the law. This was intended to allow for a larger operating range when testing the manufacturer's vehicles. However, Sections 1i Para. 2 S. 2 and 3 of the StVG stipulate that the KBA can restrict the operating range by means of an ancillary provision to ensure safe operation.

Pursuant to Section 1i (1) No. 3 of the StVG, the operation is approved exclusively for testing purposes. This is intended to emphasize the research character of the permit and clarify that the operation may not be used for commercial purposes. Testing passenger transportation is possible and should be noted in the application. In accordance with Section 1i Para. 1 No. 4 b) of the StVG, the operation must be permanently monitored by an on-site technical supervisor.

Complications

Although the law on autonomous driving has been in force in Germany for almost two years, the KBA has not yet issued permits for vehicles with autonomous driving functions. The biggest problem is that currently no manufacturers can produce a large number of vehicles and meet all technical requirements of the legal framework. There are still many research projects in Germany that aim to integrate autonomous shuttles into public transport as an on-demand service; however, delays are expected because no suitable vehicles are available.

Another problem arises in the implementation of Technical Supervision. As previously explained, the monitoring it provides in the background is a mandatory component of the concept. However, the monitoring density, that is, the number of vehicles that one technical supervisor can or may monitor, has not been defined by law. Therefore, the issue remains controversial. A monitoring ratio of 1:1 is not economically attractive to public transport operators. There would be no reduction in of the number of required personnel, and the cost of purchasing autonomous driving systems would render them unprofitable. It seems sensible to start with a low ratio of 1:5, for example, and to expand this ratio depending on the state of research. Higher ratios make the use of autonomous vehicles more economically viable.

European regulations

Since 2022, a vehicle manufacturer can also apply for EU-type approval, which applies throughout Europe. The basis for this s the Implementing Regulation(EU) 2022/1426. [17]

At the request of the manufacturer, the KBA can provide an EU-type approval for motor vehicles with autonomous driving functions in a small EU series. Article 1 of the Implementing Regulation EU 2022/1426 covers fully automated vehicles in categories M and N. The small series may include a maximum of 1,500 vehicles.

EU-type approvals may be granted to vehicles designed and built for passenger or freight transport within a defined area or to vehicles designed and built for passenger and freight transport on a defined route with fixed starting and ending points. Vehicles that have a fully automated driving mode for parking applications in predefined parking facilities are also eligible. The regulation governs the technical specifications and requirements of the motor vehicles. Annex III, Part 2 of the regulation contains a description of the application documents that must be submitted.

The manufacturer is required to submit a documentation package that describes the basic design of the vehicle with an autonomous driving function in a general and functional manner. The package should give access to the means by which it is connected to other vehicle systems or directly controls output variables. An operation manual for the autonomous driving function must be included. Information on the hardware and software external to the vehicle and the remote functions must also be included. The manufacturer must also submit a safety concept that confirms that the vehicle does not pose any disproportionate risks to vehicle occupants and other road users. A valid certificate of conformity for the safety management system is also required.

Applicants must also complete an initial assessment. The initial

17 COMMISSION IMPLEMENTING REGULATION(EU) 2022/1426 of 5 August 2022 laying down rules for the application of Regulation(EU) 2019/2144 of the European Parliament and of the Council as regards uniform procedures and technical specifications for the type-approval of the automated driving system(ADS) of fully automated vehicles, https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32022R1426.

assessment is a KBA pre-approval procedure to determine whether the future approval holder is suitable. It is mandatory to use model information documents deposited in Annex I of the Regulation.

Area of operation

According to Article 1 of the Regulation, the EU approval is only intended for vehicles that operate within a fixed area or on a fixed route. Depending on the EU member state in which the operating area is located, national regulations on the operating area must be considered. For vehicles used in Germany, Section 1d(2) of the StVG applies. The application for the approval of the operating range must be submitted to the locally responsible state authority. The EU approval is the basis for the approval of the national operating range(Section 9 AFGBV).

Technical Supervision

The manufacturer decides whether Technical Supervision is provided for in the vehicle concept. If Technical Supervision is provided, the legal requirements depend on the respective national regulations.

If the vehicle is to be operated in Germany, Technical Supervision is mandatory(analogous to Section 1e, StVG). This must satisfy the requirements of Sections 13 and 14 of the AFGBV. The assessment of technical supervision is not the responsibility of the KBA but of the authority responsible for the approval of the operating area.

Smart Mobility legal developments

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There are also constant legal adjustments and new laws for smart mobility and innovative digital mobility services in Germany. Consequently, mobility as a service(MAAS) has become increasingly important in the implementation of the mobility transition in Germany. The following section will focus on the Amendment of the Passenger Transportation Act(Personenbeförderungsgesetz–PBefG) as well as the laws on handling mobility data and the drafting of a new mobility law.

Innovations in German Passenger Transportation Law

The amendment[1], announced on April 27, 2021, encompasses numerous changes within the PBefG[2] and related regulations.
This amendment aims to address the growing emergence of "alternative service models" that present significant challenges to traditional public transportation(ÖPNV) in Germany[3].
These challenges include app- and smartphone-driven models that enable demand-oriented provision of transportation services through intelligent bundling. These services are bundled and offered to multiple passengers at different destinations independent of predefined routes[4].

The previous lack of clear categorization of flexible service models within the transportation system was addressed by the PBefG amendment, primarily through the introduction and definition of two new transportation forms: scheduled on-demand transportation as part of public transportation(see Section 44 of the PBefG) and bundled on-demand transport as occasional transportation outside public transportation (see Section 50 of the PBefG)[5].

These changes are designed to ensure a fair balance(the so-called "level playing field")[6] between different modes of transportation[7] and provide states and municipalities with appropriate control mechanisms.

Scheduled on-demand transport under Section 44 S. 1 PBefG allows for the transportation of passengers with prior requests, without fixed route lines between specific boarding and disembarking points, and within a designated area and specified service hours.

This new form of transportation integrates platform-based on-demand

1 Act on the Modernization of Passenger Transportation Law of 16.4.2021(BGBl. I 822).

2 Passenger Transportation Act in the version of the announcement of 8.8.1990 (BGBl. I 1690), which was last amended by Art.1 of the Act of 16.4.2021(BGBl. I 822).

3 BT-Drs. 19/26175, 1.

4 BT-Drs. 19/26175, 1.

5 BT-Drs. 19/26175, 1.

6 BT-Drs. 19/26175, 23.

7 See Heinze/Fehling/Fiedler, PBefG, § 2 Rn. 49 on the concept of types and the type constraint in the PBefG.

transportation offerings into public transport for the first time, giving transportation service providers the opportunity to establish efficient demand-driven services that complement traditional line transportation. Outside of public transport, bundled on-demand transport ensures that new occasional transportation forms(e.g., ride-pooling) attain legal approval. This allows for individual seat rentals and the bundling of passenger requests along similar routes.

By enshrining these provisions in the law, both service offerings now undergo changes in their approval processes and requirements according to the PBefG. Thus, the previously required recourse to the provision in Section 2 Para. 6 of the PBefG[8] and the so-called experimentation clause in § 2 Abs. 7 of the PBefG("modified type constraint")[9] or other special permits are no longer necessary for the mentioned service forms. For scheduled on-demand transport according to Section 44 S. 1 of the PBefG and for bundled on-demand transport according to Section 50 Para. 1 S. 1 of the PBefG, the requirement for approval will now be based on Section 2 Para. 1 No. 3, Section 2 Para. 1 No. 4, and Section 46 Para. 2 No. 4 of the PBefG.

Scheduled on-demand transport

Section 44 of the PBefG sets clear criteria for on-demand transport services for the first time in passenger transport law and integrates them into local public transport. According to Section 44 S. 1 of the PBefG, on-demand services operate between certain boarding and alighting points within a defined area and at defined times, subject to prior ordering via an application.

This means that many on-demand services that previously did not fit into a specific type of service are now included as a special form of scheduled service in accordance with Section 42 of the PBefG. The new on-demand service will be introduced as an attractive replacement for scheduled services, especially on the outskirts of conurbations and in rural areas. This is particularly true in service areas where low demand regularly prevents economically viable public transport. As it is classified as a scheduled service, the corresponding rights and obligations(in particular, comprehensive accessibility) also apply. Surcharges may be levied on regular service tariffs(Section 44, sentence 3, PBefG).

8 Art. 1 Law on the Amendment of Passenger Transportation Regulations of 14.12.2012(BGBl. I 2598).

9 See also Eickelmann/Krampitz/Bußmann-Welsch/Stegmaier, Rechtliche Rahmen bedingungen autonome Shuttles(Hub Chain), 2020, 14.

Bundled on-demand transport

The central feature of bundled on-demand transport is the bundling of several transport orders along similar routes(Section 50(1), S. 1, PBefG). In practice, bookings are usually made via applications that can also be used to identify transport routes and destinations. The main transport policy function of this form of service is the bundling of separate transport orders along a route, which is intended to contribute to the further containment of motorized private transport. In the future, bundled on-demand services(Section 50, PBefG) should also ensure regular eligibility for the approval of new forms of service in the area of shared use(e.g., Uber) other than local public transport. As part of the occasional services, they are not subject to the rights and obligations of scheduled services. This new form of transport is largely determined by local authorities.

In urban and suburban transport, the licensing authority must set a bundling quota in agreement with the public transport authority. The quota sets the proportion of bundled transport orders to be fulfilled in a given period within the area in which the transport is operated (Section 50(3) S. 1 PBefG). It must also provide regulations on minimum transport charges that ensure sufficient distance from the transport charges of the respective local public transport systems(Section 51a(2) S. 1 PBefG). To this end, the respective public transport authorities, companies operating in the district of the licensing authority, and the chambers of industry and commerce must be consulted (Section 51a(3) S. 1 PBefG).

Mobility data

Approach for a new Mobility Data Act

Following a broad-based stakeholder consultation, the BMDV developed and published initial key points for the new Mobility Data Act(Mobilitätsdatengesetz–MDG)[10].

The regulation of mobility data is strongly influenced by European legal requirements, including the directive on the introduction of intelligent transport systems in road transport and their interfaces with other modes of transport.[11] The aim of the BMDV's legislative initiative is to implement existing national and EU requirements that provide data

10 https://bmdv.bund.de/SharedDocs/DE/Anlage/K/eckpunkte-mobilitaetsdatengesetz.pdf?__blob=publicationFile.

11 Directive 2010/40/EU of the European Parliament and of the Council of 7 July 2010 on the framework for the deployment of Intelligent Transport Systems in the field of road transport and for interfaces with other modes of transport Text with EEA relevance, https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32010L0040.

accessibility at the National Access Point(NAP) in a bundled manner. Based on the mobility data infrastructure, the law should not only coordinate the provision of data in the area of multimodal travel, including the Passenger Transport Act (PBefG), but also include additional transport infrastructure data that must be made centrally accessible at the NAP in accordance with EU law. It is also intended to regulate what data companies must provide in the future, when, and in what form. This should include travel and local transportation infrastructure data, such as scheduled timetables, stops, and information on the occupancy of truck parking spaces on freeways or construction sites. The vehicle data should not fall within the scope of the MDG.

Mobility data should be openly available free of charge to users via the NAP. The maximum permissible number of real-time data retrievals (rate limit) should be set to protect technical systems from overload. In addition, there will be a requirement to use the "Creative Commons Public Domain Dedication"(CC0 license) for further data use. There should only be an obligation to provide data if it is actually available(rather than an obligation to collect data).
The decision to collect data should be the responsibility of the transport companies and public transport authorities. The tasks of the mobility data coordinator should be defined according to the law.

The federal government has assumed a more active role than ever before. Examples of tasks mentioned include the definition of quality standards and support for data holders operating nationwide and internationally. The aim should be the uniform bundling, structuring, quality assurance, and publication of data via a data coordinator.

However, consumer protection associations view this approach as insufficient.[12] Among other issues, they have criticized the lack of rules regarding access to vehicle data. The currently established privileged access of vehicle manufacturers to vehicle data must be eliminated, as the de facto data sovereignty of car manufacturers restricts the freedom of choice for consumers and prevents competition and innovation.

Only with fair, consumer-friendly, and independent access to vehicle data can the data that are important for the mobility transition remain in Europe. However, the Association of German Transport Companies (Verband Deutscher Verkehrsunternehmen - VDV) fears that this might

12 https://www.vzbv.de/sites/default/files/2023-08/23-08-04%20STN%20Mobilitätsdatengesetz_final.pdf

create competitive disadvantages for its members.[13]
It argues that privately organized companies must be prevented from achieving profit margins in sales when the transport associations undertaking all of the investments and bearing the costs in a "business that cannot be operated profitably."

New legislative approach: Mobility Laws

Unlike the EnWG, the German transport law lacks comprehensive objectives for road, rail, air, and inland waterway transport. It also lacks horizontal and cross-modal planning and vertical coordination between various levels of government. German transport planning is based on the extrapolation of historical trends and bottleneck analyses.

Instead of uncoordinated individual planning and financing, there should be more integrated transport planning in which the individual means of transport are treated as part of an overall transport system. This lack of an overarching policy strategy in the transport sector could be countered by introducing a federal mobility law[14] that balances ecological and public welfare criteria. In concrete terms, this means that planning authorities would have more leeway to implement the transport transition.
Mobility laws have already been passed at the state level[15], in places like Berlin. § 1(1) of the Berlin Mobility Act[16] states: "The purpose of this Act is to preserve and further develop a safe, barrier-free transportation system that is geared towards the mobility needs of the city and surrounding areas and is designed to be urban, environmentally, socially and climate-friendly […]. The purpose of the law is also to ensure the efficient and economical use of the scarce resource of public road space."[17]
The mobility regulated by this Act encompasses the special requirements of all mobility groups: pedestrians, cyclists, local public transport, commercial transport, and private motorized transport; it also ensures the priority of the environmental alliance(Umweltverbund) (see Preamble of the Berlin Mobility Act)[18].

A federal mobility law does not yet exist in Germany. However, at the state level, Brandenburg is developing its own mobility law[19]. In this respect, the federal government's task is to take up regulatory proposals from society, examine them, and make sensible additions to the legal framework under traffic laws.

13 https://background.tagesspiegel.de/mobilitaet/kampf-um-geschaeftsgeheimnisse-1

14 Federal association Verkehrsclub Deutschland e.V., Proposed legislation on the Federal Mobility Act(Bundesmobilitätsgesetz - BuMoG), 2021, https://www.vcd.org/fileadmin/user_upload/Redaktion/Themen/Bundesmobilitaetsgesetz/Hermes_Kramer_Weiss_Gesetzentwurf_BuMoG_final_nach_letzter_AEnderung.pdf

15 The federal republic of Germany consists of 16 federal states.

16 Berliner Mobilitätsgesetz, Vom 5. Juli 2018* Stand: letzte berücksichtigte Änderung: mehrfach geändert, Abschnitt 5 abgeändert zu neuem Abschnitt 5 mit §§ 60 bis 68 und Abschnitt 6 mit § 69 durch Gesetz vom 04.10.2023(GVBl. S. 337), https://gesetze.berlin.de/bsbe/document/jlr-MobGBErahmen.

17 § 1(1) 2 Berlin Mobility Act.

18 https://gesetze.berlin.de/bsbe/document/jlr-MobGBEV1ELS.

19 https://mil.brandenburg.de/mil/de/presse/detail/~05-09-2023-kabinett-beschliesst-lnvp-und-mobilitaetsgesetz#.

Conclusion

The PA had far-reaching consequences for European and German climate legislation and the transportation sector. As signatory states can decide how high their CO2 reduction targets should be and what measures they want to take to achieve the goals of the agreement, it is up to the national governments, the corrective powers of society, and, if necessary, legal proceedings to ensure that national climate laws are designed in a target-oriented manner and consistently pursued.

The European Green Deal is an important EU initiative. Many proposed legal acts have already been adopted or are about to be. However, these must not be weakened significantly in the course of the EU legislative process, and the implementation of the directives and application of the regulations in the Member States must be consistent. Otherwise, legal proceedings before the ECJ or expensive compensation payments, as with the failure to meet the ESR targets, will place an additional burden on national budgets after 2030.

The charging point market must continue to develop as part of the energy transition for vehicles. At present, legislation still focuses on the installation of charging points and the establishment of a barrier-free user experience at charging points. However, as the market develops, more regulation is required to ensure effective market and pricing mechanisms.

Autonomous and connected driving can also contribute to the mobility transition if the momentum created by the new legal framework in Germany is utilized and the new technology is developed for innovative mobility services. Public transport will benefit from this, and private transportation can be reduced. However, international regulations are required to make autonomous driving accessible across national borders and thus create an incentive for manufacturers to drive technical development forward even faster. It is time to achieve the ambitious goals that the industry and transport providers have set themselves so that the mobility transition can succeed.

Smart mobility and MAAS, such as scheduled and bundled on-demand transport, are also important elements for a successful national and international mobility transition. They can encourage people to say goodbye to private cars. Public transport must be made more attractive in the future and the range of services must be expanded. On-demand services are particularly helpful for expanding the diversity of services in rural areas. In addition, increasing amounts of mobility data must be used sensibly and be easily accessible. Politicians in Germany and the EU have now also recognized that mobility data is the “oil” of the mobility transition and must be used to make new services safer, facilitate intermodal transport, and increase efficiency.

This approach to the mobility law is convincing. Although the implementation of these innovative planning and legal approaches remains uncertain, they represent an interesting approach for meeting the challenges of the transport transition in the future.

Legal and Institutional Improvements in South Korea

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Introduction

The Seoul metropolitan area(SMA) faces congestion and pollution due to traditional work patterns and suburbanization. Infrastructure-oriented solutions sometimes exacerbate these issues and concentrate economic activity. Mobile-based vehicle sharing and CASE(Connected, Automated, Shared, Electric) technologies are innovative alternatives; however, they do not reduce passenger vehicle demand. Public transport use has declined during the COVID-19 pandemic, and platform service competition has led to conflicts and regulatory challenges. In March 2023, South Korea passed the Act on Support for Mobility Innovation and Revitalization to promote mobility transformation through advanced technology integration.

The law mandated advanced mobility surveys, government plans, regulatory exemptions, pilot project supports, and data sharing; it established research institutions and promoted start-ups and international collaboration. To ensure the success of the mobility transformation, South Korea must invest continuously, revisit fare regulations, support Peer-2-peer mobility, deregulate communication bandwidth, promote open data, implement flexible pilot project rules, and strengthen legal and institutional frameworks.

These efforts are vital for resolving conflicts, bridging digital divides, ensuring cybersecurity and privacy, and preventing AI misuse and monopolies.

Background of Mobility Transformation (MT)

Prior to the pandemic, it was common for residents of major South Korean cities to follow a traditional five-day workweek routine, often entailing long commutes via highways or public transportation modes such as urban rail, subway, and buses.

This scenario gave rise to elevated housing costs in the city centers, where numerous workplaces were concentrated, and subsequently contributed to heightened population density and congestion. Consequently, an increasing number of individuals started looking for more affordable housing options in the suburbs, further fueling the trend toward suburbanization.

In a proactive endeavor to alleviate congestion, extensive infrastructure, including road networks and urban rail systems, was developed to enhance accessibility. Regrettably, these initiatives have frequently yielded unintended detrimental consequences, including heightened social costs, escalated congestion, and increased air pollution.

Moreover, the implementation of policies such as Avoid-Reduce-Shift, designed to discourage private car usage, an important source of congestion, has yet to yield the anticipated improvements.

Despite numerous efforts to reduce congestion in fast-growing cities, the desired improvement remains elusive due to the multifaceted nature of the problem.

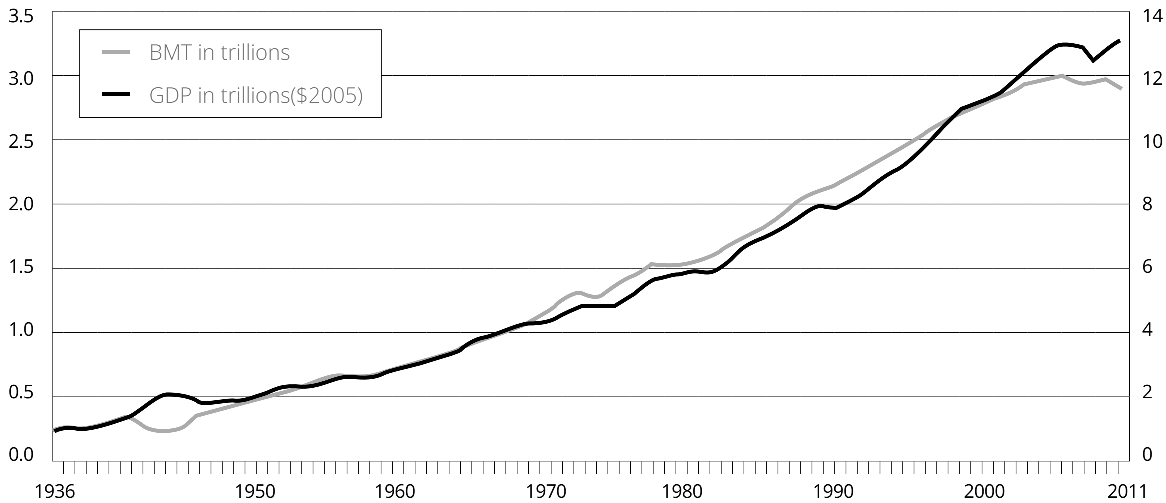

Figure 1. Relationship between VMT and GDP during 1936-2011 in the US.

Source: FHWA, USA

While congestion results in various social costs, it is also a byproduct of the bustling economic activity that characterizes such cities. Figure 1 below compares US GDP growth and total vehicle miles traveled(VMT) over 75 years from 1935 to 2011; the trends match except for some periods(Ecola and Wachs, 2012).

This complexity makes it challenging to reduce congestion. Policymakers and planners usually face a tradeoff between socioeconomic growth and inefficiency caused by congestion; they are typically hesitant to take actions that might reduce growth.

Despite extensive efforts aimed at easing congestion in the SMA area, including significant investments in infrastructure to mitigate peak-hour traffic during long-distance commutes, these initiatives have inadvertently increased migration to this region. This migration reduced the population of the provinces, resulting in a loss of job opportunities and further congestion in the already bustling metropolitan area.

First Phase of Mobility Transformation: Technology-oriented CASE

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Introduction of CASE

Since the introduction of the iPhone in 2007, the concept of vehicle-sharing on mobile platforms has gained immense popularity. Recently, this shared transportation trend has evolved to include electric bicycles, electric scooters, personal mobility devices(PMs), and Demand-Responsive Transportation(DRT) services.

The advent of the 4th Industrial Revolution marked the onset of the smart mobility era, characterized by the transformative pillars of CASE: Connected, Autonomous, Shared, and Electric technologies(Minshall, 2022). These innovations promise to create opportunities to mitigate societal burdens stemming from transportation, including traffic congestion, traffic accidents, excessive oil consumption, and the pressing issue of greenhouse gas emissions. This paradigm shift in mobility is expected to initiate a new era of sustainable and efficient transportation.

Recently, CASE technologies have moved from concepts to real-world applications. Notably, the development of Vehicle-to-Everything(V2X) technology is currently underway, with major players such as top OEMs and Google Waymo have engaged in a global race to perfect autonomous vehicles. Hyundai Motors is making significant strides in preparing to test a Level 4 autonomous vehicle in the bustling and traffic-laden district of Gangnam, Seoul.

The evolution of autonomous driving technology is not limited to passenger cars; it has permeated other sectors such as buses, Urban Air Mobility(UAM), and drones. Simultaneously, the landscape of shared transportation is transforming into Mobility as a Service(MaaS), providing new and innovative ways for people to move. Remarkably, the electric vehicle industry has experienced unprecedented growth worldwide, despite the challenges brought about by the COVID-19 pandemic.

In the wake of the pandemic, a captivating urban trend is taking root: the rise of platform urbanism. This transformative shift is primarily driven by reliance on digital platforms, such as Zoom and Uber, for work, meetings, shopping, and transportation. According to a noteworthy report from The New York Times, this phenomenon appears to be evolving into the "new normal," reshaping the way we interact with our urban environment.

Effects and Limits of CASE

The first phase of the mobility transformation process has resulted in several changes in how people live and interact with transportation. On the positive side, users now enjoy a more comfortable and secure mobility experience, centered on their needs. For instance, ride-hailing applications are a popular example of platform-based shared mobility services that improve user utility by reducing waiting times through app-based reservations. By making it easy to find and book a ride on demand, ride-hailing apps save time, reduce frustration, and allow users to reach their destination more quickly and efficiently.

Simultaneously, this transition has fueled a surge in competitiveness within the automobile industry, leading to the emergence of innovative mobility solutions and services.

However, the mobility transformation exemplified by CASE systems, still has several limitations. Notably, it has not reduced the demand for passenger vehicles. Instead, there has been a substantial decline in the number of public transportation users, particularly during the COVID-19 pandemic, whereas the decrease in the number of passenger cars was relatively modest.

Furthermore, the emergence of platform-based sharing services has intensified competition for market dominance, sparking conflicts between the traditional taxi industry and new entrants. Notably, Lime, a prominent PM company, exited the South Korean mobility market due to the tightening of regulations aimed at addressing the rising number of accidents.

South Korean Promotion of Mobility Transformation - Act on Mobility Innovation & Revitalization

CASE has emerged as a promising yet not entirely exhaustive substitute for conventional infrastructure-centric policies that primarily target specific user convenience concerns. In this section, we will present the legal and institutional endeavors initiated by the South Korean government to propel mobility transformation, with a central focus on the 2023 Act on Support for Mobility Innovation and Revitalization.

Establishment of the Mobility Bureau

In 2020, the South Korean government unveiled its visionary New Deal plan, which included ambitious goals for the expansion of data-, network-, and AI-driven smart mobility services. Building on this framework, in 2022, the Ministry of Land, Infrastructure, and Transport(MOLIT) announced a significant shift from supplier-focused transportation policies to a more user-oriented approach to mobility.

As a concrete step toward achieving these objectives, MOLIT established the Mobility Bureau in late 2022. This strategic development was intended to establish a robust institutional framework that provides a solid foundation for effective implementation of consumer-oriented mobility policies. Nevertheless, there are still areas that require continued attention and enhancement to ensure the successful realization of these visionary pursuits in the years ahead.

Act on Support for Mobility Innovation & Revitalization

In March 2023, a significant development took place as the National Assembly passed the Act on Support for Mobility Innovation and Revitalization. This landmark legislation has a twofold mission. First, it identifies and promotes existing innovative services that will pave the way for future transportation advancements while safeguarding the public's right to mobility.

Second, it encourages regulatory reforms to integrate rapid technological innovations seamlessly into transportation systems and services, resulting in a remarkable improvement in both the accessibility and efficiency of public transportation while also fostering and supporting private initiatives in the realm of mobility innovation.

Key Points of the Act

The key points of the act include
1) annual surveys of advanced mobility (Article 5);
2) regular establishment of government-level mobility improvement plans(Article 6);
3) regulatory exemptions(Article 12);
4) administrative, financial, and technical support for pilot projects(Article 15); and
5) the obligation to submit data collected during the project to the government (Article 16).

The bill includes several crucial articles.

Article 5 - Annual Surveys of Advanced Mobility.
The bill mandates annual surveys to assess improvements in advanced mobility.

1. Advanced Mobility Deployment and Service Status: Assessment of the current state of advanced mobility service dissemination.
2. Advanced Mobility Infrastructure Implementation and Administration: Evaluation of the progress in deploying and managing advanced mobility infrastructure.
3. Trends in Advanced Mobility Technology Development: Analysis of emerging technology trends within the advanced mobility sector.
4. Public Satisfaction with Advanced Mobility Services: Measuring public contentment with the quality and accessibility of advanced mobility services.
5. Factors Driving Advanced Mobility Revitalization: Identifying the key factors vital for revitalizing advanced mobility, including integration status with existing mobility services across regions, transportation axes, and time zones. Infrastructure installation and management updates. Policy demands shaping the advanced mobility landscape.

Article 6 - Mobility Enhancement Plans & Implementation:

This initiative establishes an iterative process for crafting government-level strategies and practices dedicated to enhancing mobility.

1. Scope of Mobility Enhancement Plan: Definition of the geographic and temporal boundaries of the mobility improvement plan
2. Regional Transportation Axis, and Time Zone Analysis: Examination of current mobility status, service levels, and improvement strategies across different regions, transportation routes, and time zones.
3. Comprehensive Expansion Plan for Advanced Mobility Means and Infrastructure: Elaborate strategy for the growth and development of advanced mobility resources and infrastructure.
4. Promotion System and Financial Resource Procurement and Management: Mechanisms for advancing the plan and securing financial resources, including procurement and operational aspects.
5. Financial Support to Local Government: "The Minister of Land, Infrastructure, and Transport has the authority to assess the feasibility, validity, and suitability of the mobility improvement plan. Furthermore, the Minister is empowered to offer financial support to local governments that exhibit outstanding results in their implementation of improvement projects."

Article 12 - Streamlined Regulatory Exemptions:

The bill provides regulatory exemptions, simplifying the process for a special case for demonstration in this field.

1. Application to conduct a special case for demonstration: Allowance to apply when no existing standards align with the relevant technology or services in the relevant statutes, or applying the existing standards is inappropriate, or seeking permission through other acts and subordinate statutes is not feasible.
2. Grant of a special case for demonstration: The Mobility Innovation Committee decides on granting special demonstration cases by considering the following factors: a) business implementation plan; b) innovation and user benefits of new mobility means, infrastructure, services, and technology; c) potential for future growth in related markets; d) likelihood of damage that is hard to recover from during the demonstration and adequacy of compensation measures; e)

impacts on people's lives, health, safety, environmental balance, regional development, and the secure handling of personal information; and f) any other pertinent matters required for granting special demonstration cases.

3. Liability: A person granted a special case for demonstration must obtain liability insurance to cover potential human and material damages arising from the project. If obtaining insurance is not possible, they must create a compensation plan after consulting with MOLIT. In a special case, if the provider of mobility means, infrastructure, services, or technology causes damages without intent or negligence, they are not liable for compensation.

Article 15 - Comprehensive Support for Pilot Project:
MOLIT can provide administrative, financial, and technical support for pilot projects to foster experimentation and innovation.

Article 16 - Transparency in Data Sharing:
A key obligation is the submission of project-generated data to the government to ensure transparency and to reveal valuable insights.

1. MOLIT may request that a person who has been granted a special case for demonstration or a person who conducts a pilot project submits mobility-related data generated by the execution of the project. In such cases, when personal information is included in the data, the Personal Information Protection Act applies to the collection, provision, and use of relevant information.
2. A person requested to submit data shall comply unless there is a special reason prescribed by the ordinances ofMOLIT. MOLIT shall endeavor to prepare a plan to analyze and manage mobility-related data comprehensively and provide them to the general public.

Institutional Mechanism of the Act

The bill encompasses several critical institutional mechanisms:
1) the creation of a cutting-edge mobility innovation center(Article 7);
2) the designation of a mobility-specialized city(Article 10);
3) the formation of the Mobility Innovation Committee (Article 18), which will promote R&D initiatives;

4) providing invaluable support to burgeoning start-ups(Article 22); and 5) fostering robust international collaboration(Article 23).

Article 7 - Creation of Mobility Innovation Support Center(Article 7):

In order to support mobility innovation efficiently, MOLIT may designate "public institutions," "local public enterprises," "government-funded research institutes," and "others prescribed by Presidential Ordinance" as mobility innovation support centers during the period prescribed by Presidential Decree. The center undertakes the following duties:

1. Support for the status survey of advanced mobility,
2. Establishment and evaluation of mobility improvement plans and advice and support on implementation of improvement projects,
3. Consultation and support on the establishment of mobility infrastructure measures,
4. Consultation and support related to the designation and operation of a mobility-specialized city,
5. Consultation and support on special cases of demonstration,
6. A project commissioned by the government to innovate the mobility solutions,
7. Other duties prescribed by Presidential Decree to carry out and support mobility-related projects.

Article 10 - Designation of a Mobility-specialized city:

To promote mobility innovation and industry development, MOLIT may designate a mobility-specialized city in consultation with the heads of the relevant local governments, as prescribed by the Presidential Decree. The central and local governments may provide administrative, financial, and technological support, which is necessary for mobility-specialized cities.

Article 18 - Mobility Innovation Committee:

The Mobility Innovation Committee may be organized and operated under the jurisdiction of MOLIT to deliberate and resolve the following matters:

1. Granting of special cases for demonstration,
2. Improvement of laws and regulations related to special cases of

demonstration,

3. Coordination of opinions between the heads of relevant central administrative agencies and the heads of local governments,
4. Relationship with relevant statutes, such as transportation, city, and architecture, according to mobility innovation,
5. Deliberated by the Chairperson as an important policy on advanced mobility.

Article 22 - Revitalization of Entrepreneurship:

The government may provide the following support to promote and revitalize start-ups related to the advanced mobility industry.

1. Subsidies or loans for start-up funds,
2. Providing R&D results related to advanced mobility,
3. Support for test equipment and facilities,
4. Sharing of mobility-related public data,
5. Other support prescribed by Presidential Decree: Support for office space, market development and overseas expansion, education for start-ups, tax, accounting, and law; intermediation of services provided by the public and private sector(Ordinance 20).

Article 23 - Fostering International Collaboration:

The government identifies international trends in high-tech mobility, promotes international cooperation, and supports overseas expansion of advanced domestic mobility companies.

Conclusion: Study Summary and Future Tasks

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Study Summary

Before the COVID-19 pandemic, South Korean cities adhered to a traditional five-day workweek, which spurred suburbanization and prolonged commutes, contributing to significant congestion and air pollution issues. Infrastructure-oriented measures aimed at alleviating these problems, particularly within the densely populated SMA, home to half of South Korea's population, have resulted in unforeseen outcomes such as increased traffic congestion and heightened pollution.
This intricate problem is closely intertwined with economic activity. Ironically, investments made to alleviate congestion in the SMA have inadvertently attracted more people to the region, exacerbating population decline and economic hardships in other regions.

To address the adverse effects of infrastructure-oriented investments, a new transportation solution using innovative technologies has emerged. Since the launch of the iPhone in 2007, mobile-based vehicle sharing has gained popularity and has expanded to include electric bicycles, scooters, and Demand-Responsive Transportation(DRT).

The 4th Industrial Revolution ushered in CASE technologies, which are promising solutions to traffic congestion, accidents, oil consumption, and greenhouse gas emissions. This shift is becoming a reality with V2X technology and Hyundai testing Level 4 autonomous vehicles. Autonomous technologies have been extended to buses, Urban Air Mobility, and drones. Shared mobility has evolved into MaaS, while electric vehicle sales have grown despite COVID-19.

Platform urbanism, driven by digital platforms, is reshaping urban life. The advantages of this mobility transformation include user-centered, comfortable, and secure experiences with ride-hailing apps that reduce wait times.
This has fostered technical competitiveness in the automotive industry. However, this has not reduced the demand for passenger vehicles and public transport use decreased during the pandemic. Competition among platform-based services has led to conflicts with the traditional mobility industry, such as taxis, and regulatory challenges, forcing some advanced mobility companies to exit South Korean markets.

In March 2023, Korea's National Assembly passed the Act on Support for Mobility Innovation and Revitalization, marking a significant milestone in transforming mobility. The dual purpose of this legislation was to promote innovative mobility services and seamlessly integrate rapid technological advancements into transportation systems.

The key provisions include annual surveys on advanced mobility, government-level mobility enhancement plans, regulatory exemptions, support for pilot projects, and data sharing obligations. Additionally, the act establishes critical institutional mechanisms, such as mobility innovation support centers, mobility-specialized cities, and the Mobility Innovation Committee, fostering research, startups, and international collaborations in the mobility sector.

Future Tasks

Despite the transformative influence of innovative technologies and the COVID-19 pandemic on the transportation sector, outdated regulations and industry conflicts continue to impede progress in this rapidly evolving landscape. For technology-oriented mobility transformation (CASE) to become an infrastructure supply-oriented policy alternative, the following additional efforts are needed beyond legal and institutional support.

To propel future mobility transformation, it is imperative to maintain continuous investment in technology, infrastructure, and human resources, while also securing stable funding sources for implementation. Additionally, revisiting fare regulations within the platform industry and supporting Peer-2-peer mobility businesses are pressing concerns.

The deregulation of communication bandwidth, promotion of open data policies, and implementation of a flexible regulatory framework for pilot projects should be promoted. Furthermore, comprehensive legal and institutional enhancements are crucial for resolving conflicts between traditional and emerging mobility sectors.

Simultaneously, efforts should focus on bridging the digital disparities among diverse demographic groups and regions, ensuring robust cybersecurity measures, safeguarding privacy, and preventing the potential misuse of AI and monopolistic practices by platform companies.

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Towards New Mobility Paradigms

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Introduction

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The rapid evolution of technologies encompassing the Internet of Things(IoT), artificial intelligence(AI), automated driving, and big data, collectively referred to as the Fourth Industrial Revolution, has brought about profound changes across various sectors of society. Within the field of transportation, the integration of cutting-edge technologies and socioeconomic change have driven substantial shifts in both the demand and supply of transportation services.

On the demand side, deviations from traditional transportation demand patterns are attributable to factors, such as an aging population, increased leisure travel, and a surge in telecommuting. On the supply side, the emergence of advanced and diversified mobility services is transforming the transportation industry, which has traditionally been divided into public and private transportation. This includes the sharing of transportation modes, introduction of automated driving services, and the expansion of demand-responsive transportation services.

People are questioning whether these changes in the transportation sector are beneficial to users and how far-reaching they will be. Many transportation experts recognize that the changes witnessed thus far are merely small fragments of the larger transformations that are expect to occur in the future. Preparing for and understanding the upcoming changes in the transportation sector is imperative for devising appropriate policy responses. Consequently, understanding this evolving trend is essential for making well-informed decisions at the individual, community, and national levels.

In this chapter, we explore how changes in the transportation originated and whether they are beneficial for users. We compare the traditional concept of transportation and the contemporary notion of mobility, which is widely used in society. Subsequently, we shed light on the vision and direction of mobility transformation in society.

Transportation

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Concept of transportation

Nowadays, we hear the term "mobility" frequently in our daily lives. Although we commonly use the term "mobility," we usually do not clearly distinguish it from the term "transportation." In terms of etymology, the word transportation appeared around the 15th century and meant "carry." At the time, the act of carrying was performed by a person. What moved–that is, what was carried–was an object rather than a person. In the Middle Ages, most people(about 90%), excluding the ruling class of nobles, were bound to the land on which they lived and did not have freedom of movement. Since most people did not have freedom of movement, their movement was more akin to that of objects in that they were considered objects to be carried by the ruling class. Therefore, the focus of transportation was placed on moving things quickly at low cost. The concern for movement was limited to ensuring that the objects were not damaged.

After the Industrial Revolution and into the 19th century, the meaning of the word "transportation" shifted from "carry" to "means of carrying." As the focus of transportation was placed on moving more cargo to farther places cheaper and faster, "means of transportation" was considered important. This focus involved the infrastructure required for the movement of cargo, including roads, railways, ports, and airports, as well as transportation modes such as trains and ships and, later, cars, buses, and airplanes. Furthermore, as traffic volume and the number of transportation modes increased, more attention was paid to traffic control systems for various means of transportation to enable smooth movements.

The emergence of passenger transportation

Before the Industrial Revolution, ordinary people had no means of transportation for their everyday lives other than walking. Urban areas had to be limited to a spatial scale of approximately 4 km in diameter, which is sufficient for people to travel on foot. The psychological limit on the time people are willing to travel in daily life is one hour, and the average walking speed of adults is 4 km/h. As such, urban areas where people live their daily lives were developed with a movement radius of approximately 4 km. Even today, people mainly walk in their daily lives, so the neighborhoods in which they manage their everyday lives have a movement radius of approximately 4 km. In other words, it took approximately 30 min to move on foot from the outskirts of a city to the downtown area and approximately 30 min to walk back to the outskirts. The radius of movement created a round-trip distance of approximately an hour on foot.

The temporal limitations related to daily travel have not changed significantly. However, with the Industrial Revolution, population density increased in urban areas; usable area per person gradually decreased; and traffic congestion and pollution worsened. Nevertheless, as more people flocked to cities, population density continued to increase, and urban space expanded.

Therefore, carrying people over longer distances became necessary. New transportation modes emerged in response to this social demand. Expensive personal transportation such as small carriages could not be used by ordinary people. Omnibuses(stagecoaches that could accommodate multiple people) that ran on certain routes were available to the general public, and public transportation using railways and trains emerged. In 1863, the first subway in the world opened in London. With the advent of urban passenger transportation, the average city radius expanded to about 10 km, because the average train speed at the time was approximately 10 km/h. Before the Industrial Revolution, the main object of transportation was cargo; since then, people have become the object of transportation.

However, even in the late 1800s and the early 1900s, the movement of most ordinary people could not be considered as free as it is today. As most ordinary people were very poor and had long working hours, they had very limited spare time and could not realize their freedom of movement. In other words, people traveled to work, and transportation providers carried commuters to and from the workplace in large numbers. From the perspective of transport providers, such movement of people can be seen as nothing more than the mass transport of poor ordinary people who commute. As passenger cars became more common in the early 1900s, people's travel by private rather than public transportation increased; however, most of this travel was related to essential activities, including commuting.

From carrying to travel: The emergence of "mobility"

The beginning of the "voluntary and free movement" of people involved the growth of the middle class through economic development, and the increased interest in quality of life associated with social development. In the past, people had to engage in essential work to make a living and could move only for that purpose. However, in the late 20th century, greater economic prosperity moved most people into the middle class. As people's awareness of the importance of personal life, beyond working for a living, has changed, their working hours have decreased. Personal hobbies and preferred social activities, including interactions with family or friends, have also increased. Therefore, the movement of people for these nonessential activities has also increased.
At the same time, as the economy developed and people's material needs were met to some extent, there was also a change in the long-standing social perceptions, in which the promotion of greater material abundance itself was considered the beginning and end of individual and social development. There were lively discussions about what it means to improve one's life, that is, to "develop."

The most prominent person in these discussions was Amartya Sen, a world-renowned economist and professor at Harvard University. In his famous book Development as Freedom, published in 1999, he emphasizes that the promotion of substantive freedom is the key to development. According to Sen, the basic standard of living should be maintained, but once basic material abundance has been realized, greater material abundance itself cannot be considered development. Instead, higher levels of freedom allow people to choose their own way of life, indicating greater development of society. Along with economic development and social change, this change in the perception of a better life has led to an increased interest in the level of freedom in almost every academic field.
This change has also shifted people's interest in movement from transportation to mobility. In other words, while "transportation" focuses on the "carrying" of cargo, "mobility" focuses on the "freedom of movement" that people have. As people have free will, the ability to move to a place of their choice using a method of their choice at the time of their choice for an activity of their choice has become important. In other words, mobility refers to freedom of movement, and improving mobility

refers to increasing the freedom of movement.

Interrelationship between transportation, accessibility, and mobility

The means of transportation are mainly discussed with a focus on how transportation moves people. The main focus is on how transportation can move many passengers quickly and accurately, and its significance as a means of transportation for this purpose is addressed.
By contrast, accessibility reflects the perspectives of people who travel. People travel to work; to obtain necessary goods and services at schools, hospitals, supermarkets, parks, etc.; and to meet friends and family and enjoy leisure activities. Therefore, the focus of accessibility is assessing whether people can accomplish travel for these goals affordably. Advocates of accessibility seek to increase the total accessibility of a diverse range of people in urban areas, beyond the individual level.

The core concept of mobility is a person's "level of freedom of movement." This refers to one's ability to travel where, when, and how they want to travel. Mobility, accessibility, and transportation are not mutually exclusive concepts; improving mobility requires enhancing transportation and accessibility. What differentiates mobility from the traditional perspective of transportation is that walking, rather than transportation, appears to be an important element and that the urban space people share should also be considered. This is illustrated in Figure 1

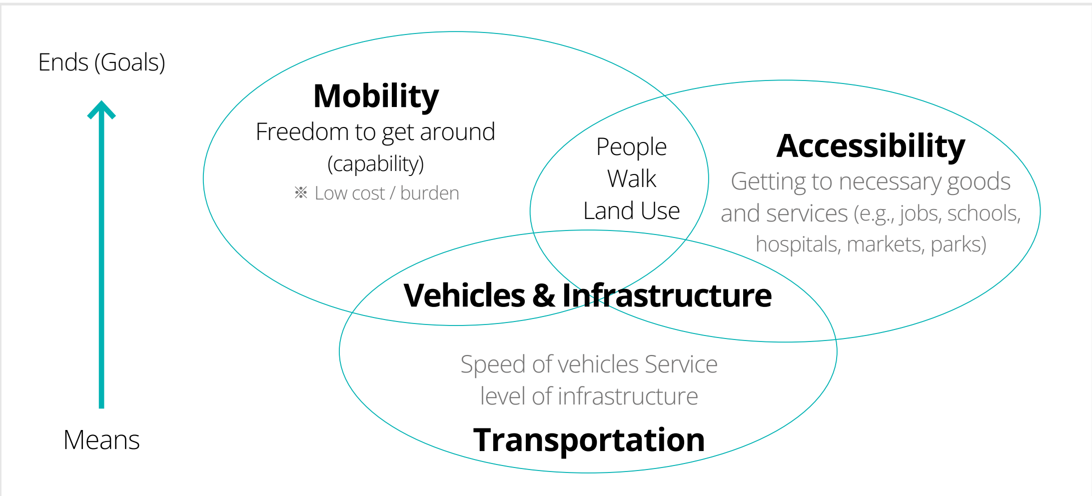

Figure 1. Interrelationships among transportation, accessibility, and mobility.

Source: Author

From transportation to mobility

As the economy develops, people increasingly desire more sophisticated and tailored transportation options that align with their individual preferences. At the same time, a social consensus is developing that mobility rights should be improved by expanding the supply of appropriate mobility services to areas that are underserved by public transit, unlike the downtowns where various transportation services are concentrated. Moreover, changing demographics have increased interest in providing mobility services to the elderly and mobility-impaired who experience inconvenience in using public transportation. These trends require constant adaptation of the current transportation system.

Mobility transformation refers to the fundamental and comprehensive changes that occur in the manner in which people and goods move. This is mainly driven by technological advancements, societal needs, and environmental considerations. Transportation modes that can reduce traffic accidents caused by human errors, such as automated vehicles, have been developed. Advanced mobility services offering improvements in security, privacy, and passenger comfort have also been introduced. The prevalence of eco-friendly transportation and the use of shared transportation are steadily increasing, together with citizens' voluntary efforts to address serious environmental issues and reduce greenhouse gases and air pollution generated from transportation.

While the means of transportation, facilities, and services available to everyone in an area are the same, mobility varies depending on an individual's situation. For example, with the same public transportation system provided to all, the elderly or the physically handicapped still have much lower mobility than younger able-bodied users. Compared with residents living in a certain area, the mobility of visitors to that area may be restricted. In the past, governments did not give much consideration to the circumstances of individual users when providing transportation systems. However, new mobility services are now evolving to meet the specific mobility needs of individuals.

From the perspective of establishing and executing national policies, it is worth noting that transportation policies are focused on improving transportation efficiency on the supplier side, while mobility policies are

focused on improving the mobility of consumers. The transportation system was mainly constructed through intensive financial investments in physical facilities, including roads, bridges, and tunnels, as infrastructure for industrial development during the early and growth stages of economic development. During this period, the focus was on building and operating a basic transportation infrastructure with the aim of quickly and affordably meeting the transportation demand generated from the perspective of total volume. Because the fares, routes, stops, and dispatch intervals of public transportation are predetermined, users face a choice of either adapting to these fixed constraints or using privately owned transportation such as cars.
During the period in which basic infrastructure and services are established and provided based on economic efficiency, gaps may arise in accessible transportation services among regions and socio-economic classes, and these may become more severe over time. In densely populated metropolitan areas, problems such as extreme traffic congestion and environmental pollution occur. Sparsely populated areas may be underserved by public transportation services, infringing on residents' mobility rights.

As the economy grows and matures, people's consumption becomes more sophisticated; individual needs become increasingly diverse; and personal interest in safety, the environment, and health increases. Accordingly, significant financial resources are invested and government policies are developed to provide customized mobility services and to resolve imbalances between regions and classes. Digital infrastructure is deployed in the existing transportation system so that various modes can be seamlessly connected, allowing advanced technology-based mobility services to be developed and provided. The private sector expands its role in the transportation industry, which in the past was led by the public sector, and meets the needs of diverse consumers. Users who have adapted their needs to predetermined transportation services can now choose the mobility services that satisfy their requirements.

Vision, Directions, and Technology for Mobility Transformation

Vision of mobility transformation

What will the mobility transformation ultimately look like? Our vision of ideal mobility is to integrate cutting-edge technology into the transportation system such that anyone can affordably travel wherever and whenever they want in a safe, fast, convenient, comfortable, and sustainable manner. In other words, the ultimate goal of mobility transformation is the realization of universal mobility services.

In the field of communications, which has significant similarities to transportation, mobile phones were initially exclusively available to the wealthy and used only by certain classes in certain places. However, as mobile phones have evolved into today's smartphones, they provide universal communication services, so that anyone can use them anytime, anywhere, as they wish, and at a low cost. Of course, the fields of communication and transportation cannot be considered identical. In the field of communication, huge initial investment costs are involved in building the infrastructure needed for phone or data use; however, after infrastructure construction is completed, the marginal cost of increasing usage is close to zero.

Transportation requires not only huge initial investments in infrastructure but also marginal costs for transporting additional passengers. However, if the power source of transportation is converted to renewable energy; drivers are replaced by autonomous driving systems; and idle transportation modes can be shared and operated, the marginal cost of transporting additional passengers can be reduced to a very low level, as in the communications field. In other words, technological innovation will enable the mobility field to realize "universal mobility services," as the communications field has done.

Directions of mobility transformation

The first important goal for the mobility transformation is decarbonized or low-carbon mobility. Regulations on carbon emissions from transportation should be strengthened, and the development of eco-friendly transportation, including electric vehicles(EVs), should be promoted. In the transportation sector, carbon emission reduction policies should be implemented, and the development of decarbonized or low-carbon transportation should be promoted. In addition to reducing the use of passenger cars and promoting public transportation, personal transportation should be converted to green transportation modes, such as walking and cycling.

The second direction this transformation should take is toward more inclusive mobility. Customized services should be provided that address the wants and needs of the transportation disadvantaged. This does not just mean people with mobility difficulties or the handicapped; it also includes a diverse range of socially vulnerable people, such as residents of rural areas, the unemployed, the poor, women, and immigrants. Mobility options that suit them should be provided to reflect their varying needs. Furthermore, even the transportation-disadvantaged should be able to get on and off and travel without assistance from others to enable them to travel anywhere without difficulties.

Third, the transformation should provide affordable mobility. The mobility services provided should not cost passengers too much. It is undesirable for mobility devices developed using new technologies to be so expensive that transportation-disadvantaged people with low purchasing power cannot access them. It is important that fares be set at an affordable level for consumers.

Finally, it is also worth noting that mobility services should be developed in conjunction with urban planning. Incorporating mobility into urban development will provide new opportunities and possibilities. Urban planning should ensure that all residents enjoy unrestricted and convenient mobility without owning personal cars. By inducing intensive development centered on hubs in which mobility is secured, the efficient use of urban space can be increased, and the utilization rate of public transportation can also be improved.

Technology for mobility transformation

First, transportation modes, including vehicles, trains, ships, and aircraft, should achieve zero greenhouse gas emissions. Zero-emission cars and trucks should be distributed; rail usage should be increased; charging facility-related technology should be developed; and infrastructure should be built. It is necessary to reduce dependence on fossil fuels, switch to eco-friendly modes of transportation, and develop technologies for transportation systems based on alternative fuels.

Second, automated driving(AD) technologies must be developed. AD technology can increase the inclusiveness, safety, and productivity of mobility. Humans require sleep or breaks during long-distance driving, whereas AD systems do not require such things. As for cargo transportation, faster delivery times will allow urban residents to consume fresher fruits and vegetables and further reduce food waste. The use of adaptive cruise control by truck drivers can reduce carbon emissions by increasing fuel efficiency, improve working conditions for overworked drivers, and reduce accident rates. Moreover, self-driving cars or automated vehicles(AVs) can help reduce parking demand, making urban areas more pedestrian-friendly and eco-friendly by replacing existing parking lots with greenspace and greenways.

Third, technologies for smart or intelligent traffic management systems that facilitate mobility based on digital technology and data should be developed. Mobility as a Service (MaaS) must be introduced to reduce carbon emissions, improve urban sustainability, and expand shared services. Public transportation systems should be improved to be eco-friendly and more inclusive.
The introduction of MaaS not only allows users to save time through seamless mobility services but also helps them reduce their transportation expenses through discounts based on a package fare system. By connecting various means of transportation, passengers can use personalized, real-time, and demand-responsive mobility services based on their needs.
If people switch from owning private cars to using MaaS, various positive externalities can be expected, including environmental improvement and a significant reduction in traffic congestion. Accordingly, technologies for real-time connectivity among various modes of transport, package fares, transparent revenue settlement systems, and MaaS operating platforms should be developed.

Conclusions

The transportation infrastructure serves as a cornerstone for the rapid economic development of a nation by efficiently handling the substantially increasing transportation demands accompanying economic growth. However, transportation infrastructure, designed with economic growth as its primary objective, has led to various social issues, such as severe traffic congestion in metropolitan areas, regional imbalances, and air pollution. As countries transition from a phase of rapid economic growth to a more mature stage of economic development, there is a growing recognition of the need for advanced and diversified transportation services that reflect the individualized needs of users.

This chapter introduced the concept of "mobility transformation" to characterize this evolving transportation system. The vision of "mobility transformation" is presented as the realization of a "universal mobility service" that enables individuals to move safely, swiftly, and affordably anytime and anywhere, similar to the accessibility provided by the telecommunications sector. The pursuit of this vision is accompanied by four specific objectives: environmental friendliness, inclusivity, affordability, and alterations in urban spatial structure. To achieve this vision, concentrated efforts to develop and implement core technologies, such as zero-emission vehicle-related technology, automated driving technology, and smart operation based on shared transportation modes, are essential.

Given that societal and lifestyle changes occur gradually, mobility transformation proceeds steadily to reflect evolving needs and socioeconomic environments and address issues within the existing system. Mobility transformation is anticipated to be a new national growth driver that can overcome socioeconomic challenges, such as population declines, aging populations, and regional and social disparities.

Public-Private Cooperation for Mobility Transformation

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Introduction

Figure 1 below shows the various mobility services and public transportation service apps that the authors use on their personal phones.
Although the authors own personal vehicles, they use services such as micro-mobility, shared cars, and high-speed rail for occasions such as long-distance business trips.

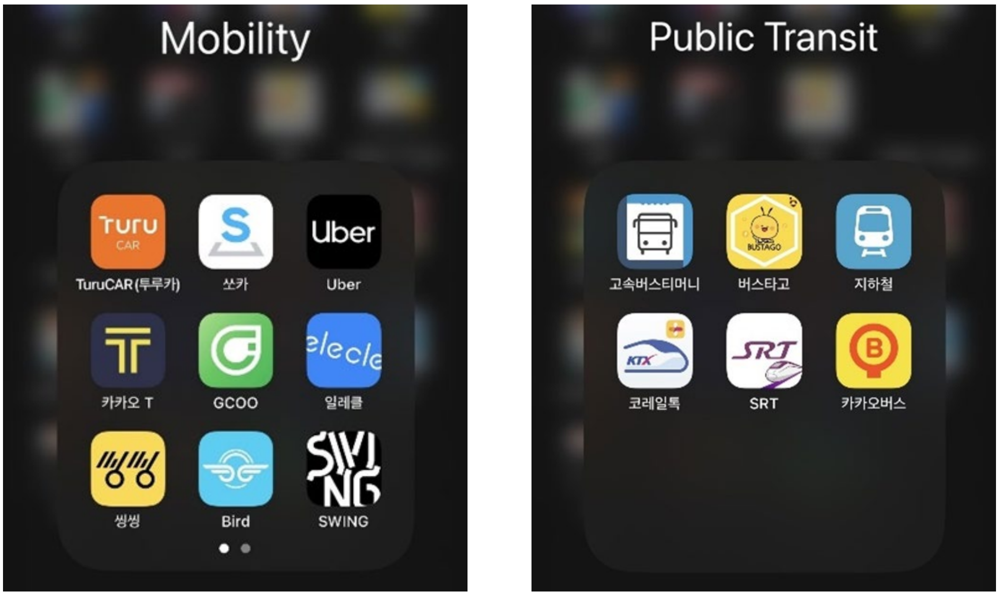


Figure 1. Various mobility and public transit service apps

Initially, there were only a few apps in use.
However, since mobility services differ across regions, users must install new apps for each service, with one of this study's authors now using over 20 apps. In order to access a service, users must install the app, register their membership, and provide a means of payment.

Having to find and use multiple service apps in each region is inconvenient for users.
Users must also learn to operate multiple apps that function differently even when providing similar services. Figure 2 below shows the user interfaces provided by two micro-mobility sharing service apps.
The maps show areas where micro-mobility vehicles can be rented and returned; however, despite serving the same area, the User Interface(UI) of each service is different, and the locations where the services can be accessed also differ. In addition to the inconvenience of using multiple apps, differences between the UIs for the apps provided by each company can cause confusion among users.

Figure 2. Confusion that may result from differences in provision for each service

Having too many services to choose from can be inconvenient for users. However, the convenience of mobility services is enhanced when these many services can be used simply. To enable the simple use of numerous services requires integrated mobility service. Mobility as a Service(MaaS) accomplishes this by connecting information related to existing public transportation modes(buses, subways, etc.) and various mobility options(micro-mobility, demand-responsive transportation, and shared vehicles).

However, South Korea's government policy, transportation infrastructure, and cultural orientation for promoting the MaaS industry and ensuring its sustainability are still inadequate.

Adjustment of interests between project participants

Unlike semi-public public transportation, mobility services are typically private businesses. If the MaaS system includes only privately operated mobility services, these platform-based businesses might be monopolized by large operators with a competitive advantage.

This would increase the likelihood of difficulties in managing the quality of the services provided. This could also lead to a competitive relationship with existing public transportation services.

Considering the development of the transportation industry, it seems appropriate to move towards the coexistence of public transportation and new mobility services within a MaaS system in urban areas where public transportation already has a significant presence. The primary role in mediating this coexistence must be played by the public sector, including local and central governments.
To achieve this, it is necessary to establish legal and institutional frameworks for the MaaS industry. The various stakeholders participating in the service industry(transportation providers, platform operators, data operators, settlement operators, administrative agencies, etc.) will share an understanding of the basic direction of MaaS implementation itself. However, in-depth discussions among stakeholders are required to ensure the scalability and sustainability of the MaaS industry.

Both private mobility services and public transportation can establish themselves as significant players in the MaaS landscape only when they ensure profitability and market share. However, if all public demands for enhancing the public nature of the service are accommodated, such as discounts for transferring between mobility modes that are similar to public transportation transfers, it may become challenging to guarantee both profitability and market share.
Excessive emphasis on public aspects may reduce the number of players participating in MaaS, ultimately leading to a return to the previous state of having too many services.

Therefore, to implement MaaS, it is necessary to form a consultative body of stakeholders, including both the public and private sectors, to build a compromise that balances the public nature and profitability of

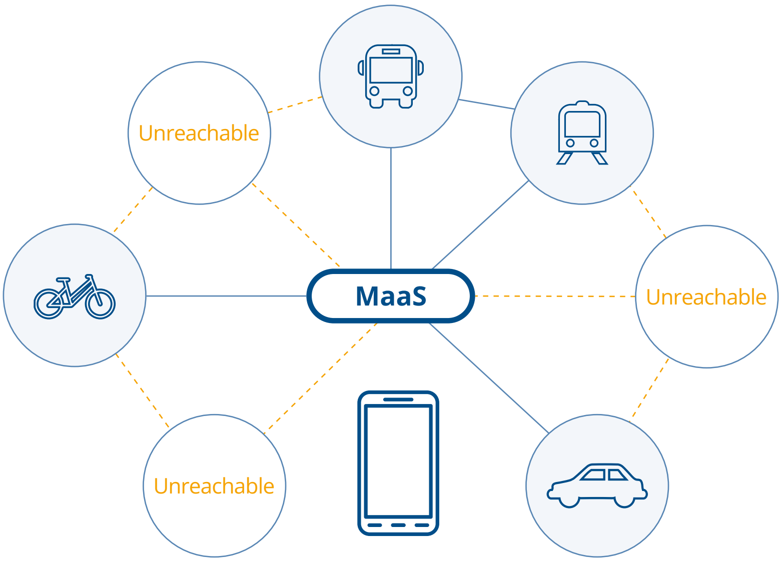


Figure 3. Public nature of mobility business vs. profitability, the reality facing MaaS implementation

the service. In addition, there is a need for the public sector to encourage the participation of various private mobility operators by supporting the construction of mobility service infrastructure, ensuring sustainable business conditions, supporting private business systems, and providing indirect fee subsidies.

Establishing mobility service governance

Governance methods for MaaS platforms and services are also a significant concern. Currently, some local governments in South Korea are exploring the development and implementation of MaaS services. However, the precise operational approach for both the platform and services remains uncertain.
The country's legal and institutional framework for defining the concept, scope, and objectives of MaaS service provision is also inadequate.

All of the technologies required for MaaS operation are already in development. Currently, it is essential to delineate the roles of the public and private sectors and establish an appropriate commercialization model for MaaS utilizing these technologies.
Conceptually, MaaS can be implemented through the following methods: 1) direct operation by local governments; 2) operation by local public institutions, such as the Korea Transportation Corporation; 3) operation

Table 1 *Various options for MaaS governance.*

Category	Local government-owned operations	Operation of local public institutions	Private operation	Hybrid operation
Operating method	· Comprehensive operation of transportation methods such as city buses, urban railways, transportation support for the mobility handicapped, and shared bicycles	· Comprehensive operation and management of public transportation, such as city buses and urban railways	· Entrusting operation to a private mobility platform operator · Or consignment operation by an alliance between private mobility industries	· Building a platform in the public domain · Various mobility service industries utilize public platforms
Pros	· Confusion can be prevented by maintaining the current system	· Seamless connection with other means of transportation · Securing expertise in computing and various fields	· Securing expertise in computing and various fields	· Potential development in various mobility industry areas
Cons	· Lack of expertise considering the characteristics of each method · Coordination with external organizations is required	· Need to transfer work to other operating organizations	· Monopoly problems may arise when entrusting operation to a specific company	· Conflicts of interest may arise · Problems with system integration such as payment, settlement, reservation, etc.

through outsourcing to the private sector; and 4) construction of a platform by the public sector with operation by the private sector, which is a hybrid method. When implementing MaaS, each local government needs to establish a MaaS platform and service operation approach that considers regional characteristics and business environments.

Furthermore, the scope of MaaS service applications and extent of integration with public transportation within MaaS will vary depending on the characteristics of each local transportation authority. In regions with a robust public transportation infrastructure, the share of public transportation in the MaaS system will be more significant, whereas in areas with limited public transportation infrastructure, private mobility services may play a more prominent role. Defining the boundaries between public transportation and various mobility services in these areas is a challenge that must be addressed through collaborative efforts between the public and private sectors.

Integrated fare plan and settlement system

For user convenience, an integrated fare system that allows simultaneous booking and payment for transportation services involving multiple modes is essential. There are various types of integrated fare plans, such as basic discount, transfer discount, and subscription. However, owing to variations in payment methods(e.g., terminal tagging and QR codes) and reservation methods(advance or real-time reservations) depending on the characteristics of each mobility mode, it is challenging to establish a standardized integrated fare system. Consequently, defining legal and institutional standards and finding global examples present difficulties.

Even if a technically integrated payment and settlement system is established, resolving competing interests between service providers and the establishment of settlement standards become complex issues, particularly when various discount benefits are offered to users. Additionally, when public transportation and new mobility services are integrated within MaaS, it is anticipated that the private mobility industry will seek subsidies similar to those provided to existing public transportation by local governments.

There may be exceptions in MaaS where only private service operators are involved. However, if local governments and public transportation are included in the scope of MaaS, the integrated rate and settlement systems will inherently become public goods. Therefore, regarding the integrated rate system issue, the central government must establish a standard framework, and each local government must establish detailed standards that reflect regional characteristics.

Data sharing

MaaS gathers and analyzes various data sources on a service platform and offers personalized transportation options to users based on the analysis results. Ultimately, the level of convenience for service users is contingent on the degree of data security and connectivity within the platform. To enhance user convenience, acquiring and analyzing a wide range of mobility data whenever possible is imperative.

However, publicly disclosing proprietary business data from individual mobility providers is fundamentally challenging. To some extent, the profitability of the business can be estimated and data can be shared with the service platform. However, this should be performed within a reasonable and acceptable range. This is a logical approach from the perspective of private businesses.

Henceforth, discussions regarding the establishment of a framework to share data will be required, which may include measures to encourage the private sector's voluntary expansion of data provision. Moreover, public institutions should play a leading role in standardization efforts for the efficient integration of various data sources.

Local governments across the country are independently promoting MaaS initiatives. However, with the establishment of a foundation for data activation and standardization, it will be possible in the future to expand the service industry through regional systems or national systems that interconnect regions.

Public-Private Cooperation for Korea-MaaS

The stir for public-private cooperation for MaaS

The widespread adoption of smartphones, proliferation of IoT devices, and emergence of AI-driven services are ushering in significant changes within the capital-intensive mobility industry. Many services aimed at enhancing economic efficiency and convenience have surfaced in the mobility market, aligning with the CASE(Connected, Autonomous, Shared, and Electrified) trend in the industry.

The CASE trend has already been widely incorporated into the domestic mobility industry in South Korea. For instance, the adoption of electric vehicle(EV) taxis continues to increase, and using apps to call taxis is no longer novel. Car-sharing and personal mobility services, which charge by the minute or hour, are expanding regionally and among various age groups. While most mobility services are still primarily point-to-point and tailored to individual needs, the rapid development of MaaS is poised to transform individual mobility from a mere mode of transportation into the central pillar of a new service industry.

Mobility technologies that feature autonomous operation and electrification such as automated vehicles(AVs) and air mobility, including Advanced Air Mobility(AAM), Urban Air Mobility(UAM), and Regional Air Mobility(RAM), are being discussed for development.
However, discussions regarding their commercialization in connection with existing mobility have yet to take place. Consumers expect an optimal combination of various mobility services in the market, making Mobility as a Service(MaaS), which guarantees the seamless integration of future mobility, an alternative to private vehicle ownership. MaaS consolidates all modes of transportation, including passenger cars, public transportation(buses, subways, high-speed trains, etc.), shared transportation(car sharing, ride sharing, etc.), Personal Mobility(PM), automated driving, and AAM, into a single door-to-door service.
It provides convenience and efficiency in travel, with the core value of providing multimodal services along an optimal route.

To address various challenges stemming from urbanization, both the central government and local governments are intensifying their efforts to integrate mobility services through initiatives such as Korea-Mobility as a Service(K-MaaS) at the national level and regional MaaS programs.

Their aim is to offer citizens optimal travel routes that seamlessly combine various modes of transportation, from reservations to payments, in a unified experience.

The scope of research required for successful implementation of MaaS is extensive, necessitating social consensus and collaboration among stakeholders. However, the starting point lies in establishing a platform that connects diverse transportation options, including both public and private services. The ultimate goal is the MaaS platform itself. Through the personalization of a multitude of transportation choices facilitated by MaaS, sharing offers a value proposition that is superior to ownership.

To prepare for the era of commercialization of shared mobility based on fully automated driving, both the private and public sectors must collaborate efficiently to develop shuttle-type transportation of various sizes proactively and to realize user-centered smart mobility services.

MaaS from the private sector(LG CNS) perspective

What is MaaS?

The definition of MaaS varies widely, but LG CNS defines it as a "one-stop service that connects all modes of transportation through a single application" (Lee, 2023).
This includes route planning, personalized product recommendations, reservations, payments, and transfer benefits, encapsulating the concept of an integrated service.

LG CNS is collaborating with the private sector, government, and local authorities to achieve the "social integration of mobility services" and bring forth MaaS services centered on "subscription products." The company is advancing its initiatives with the aim of "creating new value for customers" as a Super-App, achieved through the integration of data from both public and private transportation systems to align with circular transportation policies and foster synergy with various industries.

Why MaaS?

The proliferation of the Internet in the 1990s and the widespread adoption of smartphones in the 2000s triggered seismic shifts in various markets, offering possibilities and inspiration for numerous industries. The Internet boom laid the foundation for the emergence of the online gaming industry, which grew rapidly into colossal sector, while the smartphone era provided visionary entrepreneurs with the means to nurture their "unicorns" via the App Store, significantly contributing to South Korea's economic success. These technological revolutions have served as pivotal gateways for reshaping paradigms. The reason these two periods of upheaval succeeded in creating new markets and opportunities lies in the active engagement of consumers. These consumer-driven movements prompted suppliers to invest despite uncertainty about their potential returns, resulting in consumers experiencing daily interactions that differed from those in the past, thanks to an array of new services and products.

In South Korea, numerous innovations in the mobility sector have been implemented. Shared transportation is available nationwide and taxis can be easily hailed electronically at any time. Although the range of automated shuttles is currently limited, test beds for their commercialization are operational across the country.
These transformations undoubtedly alter the "experience of movement" in various ways. However, the services are still in a provider-oriented form; hence, the development has not yet culminated in the creation of a new industry or market. Owing to the substantial investment in assets and the need to secure demand, service providers implement policies that are predominantly supplier-centered.

This approach primarily serves to mitigate uncertainty about demand and includes entrenched benefits like bus route and taxi concessions. Consequently, mismatches between supply and demand occur across regions and times, impinging on consumer mobility rights. To address the uncertainty experienced by suppliers and to rectify this situation, there is a pressing need for significant advancements and reforms in laws and institutions.

MaaS should function like gravity, drawing providers and consumers together. MaaS operators must aggregate the diverse and uncertain demands of consumers from a comprehensive mobility perspective, and relay these demands to various suppliers. The government and local authorities must play a crucial role in initiating the MaaS industry by focusing on public transportation and offering financial support. These efforts can eliminate the uncertainty surrounding the continuity of MaaS services by encouraging voluntary price reductions by suppliers and bolstering consumer purchasing power. This approach will lead to the creation of new products and business opportunities through collaboration with various industries, such as travel, tourism, restaurants, and lodging. Mobility is the cornerstone of all industries; as a launch point, the likelihood of success is remarkably high.

The aim of MaaS is to deliver economic benefits and enhance mobility convenience to consumers while establishing sustainable business prospects for suppliers through economies of scale. Doing so can shift the mobility market, which has traditionally been supplier-centric, into a consumer-centric one and elevate the overall quality of service.

How to MaaS?

LG CNS is constructing a platform and advancing its business based on the following four core values to ensure the successful establishment of the MaaS business.

1) MaaS platform focused on public transportation

Mobility is an essential value and right that enables citizens to fulfill their basic needs for food, clothing, and shelter. While some argue that the focal point of innovation in our future travel experiences will revolve around the various services being developed or planned by the private sector, LG CNS regards public transportation, which is widely utilized today, as a crucial central element.

LG CNS believes that making private transportation, which often results in higher individual travel costs, the central focus of the future would be highly challenging. Ensuring both the fundamental rights of citizens and economic viability is imperative. LG CNS is advancing MaaS, with an emphasis on public transportation, aiming to fill the gaps left by private transportation.

2) MaaS platform with Super-App functionality

The concept of a "Super-App" is directly associated with integration, which is a fundamental requirement and function of MaaS.

Currently, many mobility services interact with consumers sporadically, often in a point-to-point manner. For instance, consumers who wish to book a taxi must install apps from all five major private taxi companies and then simultaneously request rides, ultimately selecting the service that responds first and canceling the others. Although inconvenient, this method represents an ingenious approach to utilizing the service. The same applies to car sharing and personal mobility services. The inconvenience of installing and using numerous apps has shifted the consumer responsibility, compelling them to factor in both time and cost when employing mobility services.

One of the primary reasons for this inconvenience is the difficulty that suppliers face in understanding consumer lifestyles. They struggle to analyze each individual's uncertain demands and lack confidence that observed consumer behavior will persist in the future.

Consequently, they hesitate to formulate suitable business strategies or invest to achieve economies of scale. A Super-App serves as a platform that consumers use daily, creating a virtual marketplace where consumers and suppliers interact in a 1:N, N:1 format. The MaaS platform, which incorporates the Super-App function, can amass and secure extensive data, including consumers' transportation preferences, route choices, and spending tendencies.

This accumulation can serve as the foundation of “My Data Lake.” Thus, mobility service providers can explore personalized services and various promotions for individual customers. Within the MaaS platform, competition can be based primarily on service quality.

LG CNS is enhancing its MaaS platform to enable local governments to accommodate various mobility services. In particular, to increase consumer convenience, LG CNS is enhancing the appeal of the MaaS platform by offering an AI-based optimal route search engine that includes services such as integrated reservations, personalized transportation options, and route searches.

3) Integrated subscription products and transfer discounts

A common objective of private transportation operators is to maximize the utilization rate of their mobility assets. They adjust the number of assets they own based on demand to optimize the utilization rate of these crucial business tools. They seek consistent consumer demand and prefer services that enable them to cover their fixed costs. In other words, operators favor products that can offset real-time demand costs in larger uncertain markets. Concerning MaaS platforms, the ongoing delivery of competitive mobility services by providers is the primary reason consumers remain on the platform.

Simultaneously, this has become a crucial requirement for the expansion into integrated services. Financial stability is of paramount importance for MaaS platform operators and mobility providers when offering appealing services.

This is because recovering their fixed costs allows them not only to sustain continuous services but also to introduce products based on investment efficiency. Therefore, the introduction of subscription-type products is crucial in MaaS platforms that have direct contact with customers.
Subscription-type products should be designed to offer consumers progressively increasing value over the subscription period and should be sufficiently appealing to fulfill the intended purpose and usage frequency that consumers anticipate from the MaaS platform.

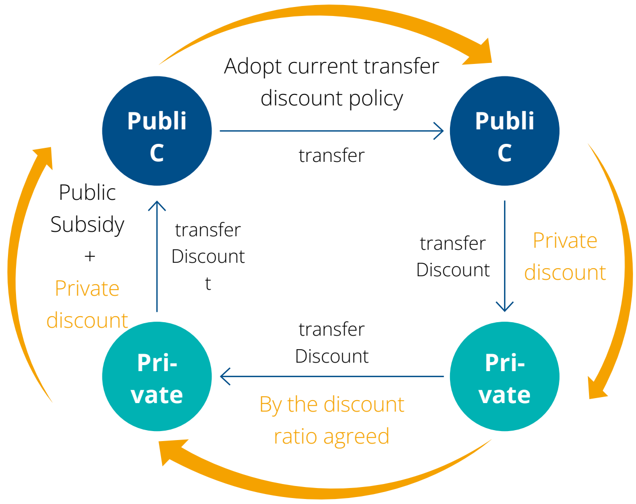
If subscription products are a major means of stabilizing the MaaS ecosystem, transfer discounts provide direct benefits to consumers. Public and private transportation differ only in the service provider; for consumers, they are just one of the many means of transportation. Transfer discounts are one way to connect private and public transportation seamlessly to offer consumers a unified travel experience.

However, because there is a significant disparity in unit usage costs between public and private transportation services, it is challenging to extend the transfer discount rates from public transportation services (e.g., buses and subways) to private transportation.

As a solution, LG CNS proposes the three-step methodology shown in Figure 3 to reach a reasonable accommodation between public and private transportation operators. To transition private car demand towards sharing-based mobility services and increase the public transportation share based on the principles of cooperation and coexistence, MaaS platform operators must also actively participate in sharing the costs associated with transfer discounts.

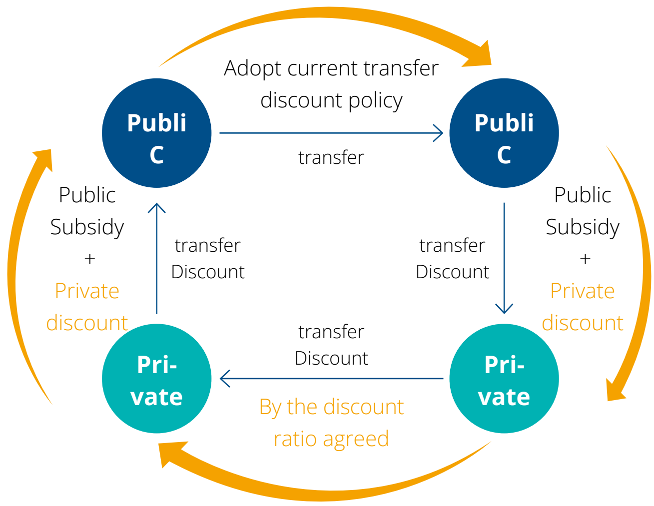
Early adoption phase

- Request subsidies for transferring private → public transportation under the pretext of Activating public transportation
- Mediate on the ratio of transfer discounts among the private mobility service provider



Mid-term stability phase

- Request expanded subsidies for the two-way transfer between public and private transportation
- Secure current public subsidies for utilizing and activating public transportation



Long-term proliferation phase

- Request to expand subsidies for providing integrated services, embracing from mobility sector to the non-mobility sector
- Promote collaboration with the policies that can make synergy with mobility services

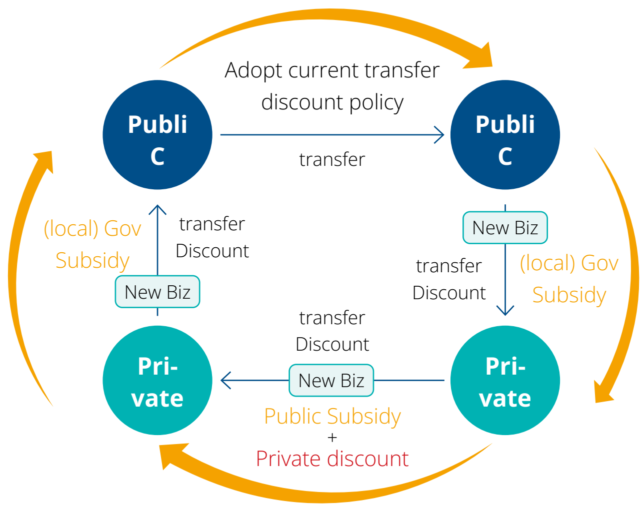


Figure 4. Step-by-step public-private cooperation system

4) Integrated settlement system

The primary reason why public and private transportation were not integrated earlier is the complexity of public transportation. Private transportation's individual mobility services are similar to planned new cities in that they are relatively simple to use and pay for and do not require complicated settlement. In contrast, public transportation is similar to the old city center model, in that it requires a much more intricate system for usage, payment, and settlement processing.
In the case of public transportation, settlement can only occur when numerous factors are considered, including business contracts among various participating stakeholders, methods for implementing financial support by local governments, and agreements on profit/cost standards.

LG CNS has a deep understanding of public transportation settlement processing, gained through its experience in establishing, operating, and maintaining T-Money Co., Ltd. After winning the national pilot city project, LG CNS is engaging in discussions with various public transportation settlement operators in each region to design a standard integrated settlement system that includes private transportation. Accordingly, the company is developing a framework for various private businesses to participate in MaaS.
The integrated settlement system is expected to play an important role in reinvesting the business opportunities and industrial capabilities derived from MaaS. If the revenue generated from a new business, such as advertising, is channeled into MaaS, a minimum distribution can be guaranteed to all providers participating in the MaaS ecosystem through an integrated settlement system.
LG CNS believes that the market resulting from MaaS is not created by the capabilities of a single operator but rather by the collective efforts of all participating operators. This is because the company believes that if a fair distribution of profits generated is possible, the challenge of uncertainty within a large ecosystem can be successfully addressed, and convergence with other markets will become feasible.

K-MaaS as seen by the public sector

K-MaaS business promotion status

In September 2022, the Ministry of Land, Infrastructure and

Transport(MOLIT) announced the "Mobility Innovation Roadmap," which focuses on institutional improvements and empirical support to align with changes in the mobility industry. The K-MaaS(project is being promoted as part of this roadmap. The goal of K-MaaS is to enhance the connectivity between public transportation (buses, railways) and private transportation(PM, car sharing, aviation, etc.), support demonstration projects, and foster service innovation and industrial ecosystem development. Construction of the system was completed in 2023, with a public pilot service scheduled from 2024 to 2026.

The K-MaaS initiative of MOLIT involves the simultaneous development of a publicly led data brokerage platform and a privately led MaaS app. The stakeholders in the K-MaaS ecosystem consist of mobility service operators, K-MaaS relay operators, and K-MaaS platform operators. Mobility service operators include various public and private providers such as bus transport companies, subway operators, car-sharing services, and personal mobility operators. K-MaaS relay operators are responsible for gathering and processing mobility-related information in collaboration with the mobility service operators. They collect real-time fleet location, operational information, payment, and settlement data, and provide them to various stakeholders in a standardized manner. Finally, K-MaaS platform operators serve as conduits for delivering new products and value to citizens by collecting and integrating information from the previous two operators.

MOLIT completed the selection of a business operator in April to establish K-MaaS nationwide with the aim of launching a pilot service for citizens by December 2023. Supermove, the operator, is currently in the process of developing the platform. The successful implementation of K-MaaS is expected to yield several positive outcomes, including improved utilization efficiency of shared transportation, increased usage of public transportation, and reduced carbon emissions. However, private operators have expressed various concerns about the K-MaaS project. Some argue that it overlaps with existing private MaaS platforms already under development or in operation, whereas others contend that the government should lead the integration of public and private transportation.

Achieving the goal of K-MaaS has proven to be a challenging endeavor, especially within a value chain that involves numerous stakeholders and competitors. To illustrate, the personal mobility service market in Seoul boasts over 30 companies, encompassing both public and private entities, offering services such as regular and electric bicycles and electric kickboards. Their services encompass a wide range of geographical coverage, time availability, and usage patterns, and the competition for survival continues.

Market share does not fluctuate primarily with the emergence of new companies; instead, it changes with the withdrawal of existing companies. As the market becomes increasingly competitive, aligning opinions among operators becomes increasingly challenging.

The most pivotal factor in the success of K-MaaS lies in engaging business operators and reconciling differences in opinions among stakeholders. The initial step in resolving this issue is for private and public transportation operators, the central government, local governments, and academia to come together and establish a unified direction.

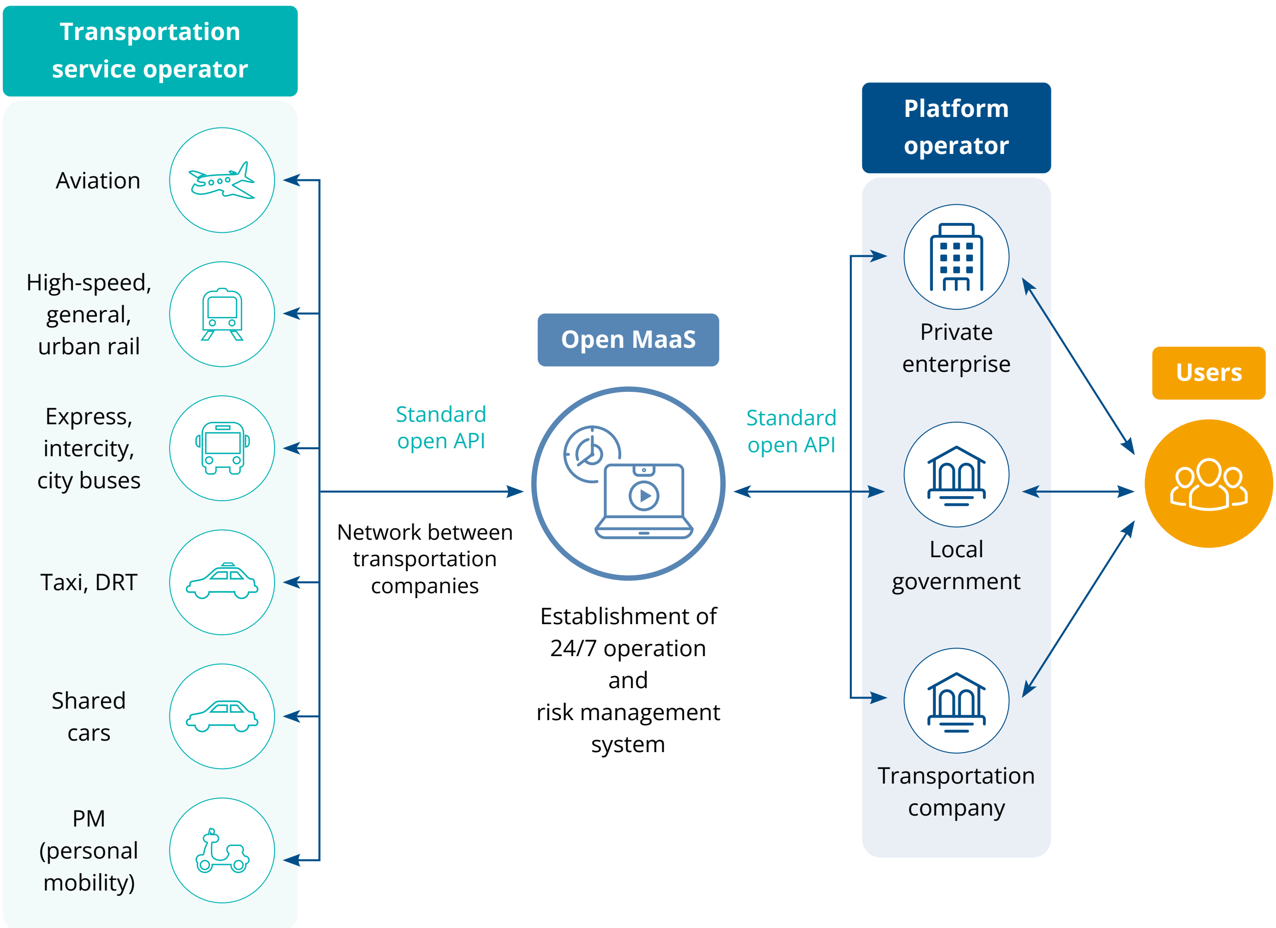


Figure 5. Korean MaaS [Source: Metropolitan Transportation Committee]

Case study of MaaS promotion based on public-private cooperation

LG CNS established the Sejong Smart City MaaS platform for MOLIT and the citizens of Sejong. It has been conducting pilot operations since 2022 and is currently preparing bundled products for multiple modes of transportation. The company provides services by linking car sharing, personal mobility, automated driving, demand response, and smart parking in the private sector.
It plans to provide integrated services in earnest from 2024 by linking public transportation, such as buses and subways. The central government, local governments, researchers, MaaS platform operators, and mobility service operators formed a consultative body and have held regular consultations every month to address differences of opinion among stakeholders and provide policy support. This case is a local government MaaS, a reduced version of K-MaaS that requires public-private cooperation. It can be used as a good benchmark case for future business promotion.

Topics for K-MaaS success

Given the intricacies of the mobility market, the key issues that MOLIT must address for successful implementation of K-MaaS are as follows.

First, priority should be given to establishing an environment that integrates various mobility services for consumers and citizens, including buses, subways, taxis, personal mobility, car sharing, UAM, and automated driving. For the efficient integration of mobility services and the growth of the mobility market, MOLIT, in collaboration with other government agencies, local governments, and transportation-related organizations, should place strong emphasis on ensuring the profitability of private mobility service providers and establishing cooperation measures based on win-win principles.

Second, there is a need to upgrade the technology applied to the mobility market to enable the convenient usage of services such as reservations and payments using smart technology. In the case of private mobility services, the application of smart technology, considering the convenience of consumers and citizens, is common; however, in the case of public mobility services, adoption tends to be slow. In MaaS, it is essential that both private and public transportation provide a seamless experience. Therefore, the Ministry of Land, Infrastructure and Transport must continue to support various projects aimed at the universal application of smart technology. Furthermore, the collected mobility data must be provided in real-time on an open platform to create a market in which the entry and exit of new mobility services are unrestricted.

Third, the continuous improvement and supplementation of policies and regulations is necessary. Regulations and policies that were established before the advent of smart technology must be updated to enable the acceptance of new future mobility options, such as ride-hailing, automated driving, and UAM. This will allow the innovative models of traditional transportation operators and new mobility operators to be harmonized. We must provide sustainable alternatives and offer financial support through revisions to existing laws.

Finally, it is necessary to create economic value through the continued growth of the mobility industry. Sharing the data collected through MaaS with all operators can provide new business opportunities for new mobility companies, including startups. In areas requiring investment from the central government and local governments, such as services for transportation-vulnerable populations, startups should be supported as they develop new business models based on open data. This will enable them to provide improved services and increase transportation accessibility. Through these efforts, we should create jobs, drive mobility-based convergence services, and support growth and innovation in the mobility industry.

Deriving key private and public tasks for successful K-MaaS introduction

While the tasks that private mobility platform operators will focus on can be implemented immediately once investment efficiency is confirmed from the company's perspective, the tasks that public institutions, including the central and local governments, should focus on are related to existing stakeholders in the industry.
These tasks are difficult to resolve in the short term and include conflict coordination, legal/institutional reviews, and securing budgets. To introduce K-MaaS successfully, it is important to determine who will play the leading role in the project among private mobility platform operators

and government agencies. K-MaaS, led by private mobility platform operators, can be promoted by building a system first and gradually expanding it based on quick decision-making. However, expanding service might also require the reworking of the system. To avoid this, a waterfall model could be used by the government to build a K-MaaS system after defining governance that includes all mobility service companies. This approach may face difficulty in reacting quickly to trends and providing timely services.

Recommendations from experts in the private mobility industry

Regarding investment efficiency and the urgency of introduction, the opinions of private mobility experts on the successful introduction of K-MaaS can be summarized as follows.
First, the most urgent tasks for the government to pursue for the successful introduction of K-MaaS are forming a consultative governance body with stakeholders in the private and public mobility industries, and establishing standards for each transportation method for data collection, connection, and openness.

Second, to promote universal transportation welfare and shared transportation, K-MaaS should consolidate the implementation channels for the policy budgets of the central and local governments. These include measures such as economical transportation cards and integrated transfers in metropolitan areas, which can serve as the basis for providing K-MaaS services. This approach can help activate K-MaaS services. The bargaining power gained through the allocation of welfare budgets can incentivize voluntary investments from the private sector, establishing a virtuous cycle that ultimately reduces transportation costs for citizens.

Third, from the perspective of private platform operators, the successful introduction of K-MaaS necessitates the establishment of an integrated settlement system that encompasses both private and public transportation. Collaboration with existing settlement operators for each mode of transportation is crucial, and ensuring transparency in settlement systems is equally important.

Fourth, public transportation should be the central focus of K-MaaS. Although private transportation can enhance citizen convenience, it can increase service costs. To ensure citizen mobility rights and facilitate the successful implementation of K-MaaS, it is essential to introduce it primarily through public transportation. Projects should be developed such that private transportation complements their deficiencies through diverse policy support.

Government agency initiatives

The details of the initiatives or projects driven by government agencies are as follows. To establish a K-MaaS ecosystem, a governance structure that includes various stakeholders(the public sector, industry, academia, and research) must be formed. At this juncture, it is crucial coordinate the perspectives of all stakeholders.

Regulations for the integration and sharing of mobility data must be established. In other words, diverse mobility data must be standardized and made available through open Application Program Interfaces(APIs).
A business structure for Korean-style MaaS must be established. First, when selecting a K-MaaS platform operator, consideration must be given to both existing private and professional platform operators centered on the local government.
Based on this, it is possible to design a business structure with clear roles and profit models for MaaS platform operators and MaaS brokerage operators, considering aspects such as the integration of members, subscription, and authentication.

A financial support policy must be instituted to support K-MaaS. Transfer discount systems for both private and public transportation along with economical transportation cards should be consolidated and leveraged.

A K-MaaS relay platform centered on public institutions must be established, with the integration and sharing of all mobility data being imperative.

Promotion tasks from the perspective of private institutions

A comprehensive summary of the tasks from the viewpoint of private MaaS platform operators follows. To ensure the sustainability of K-MaaS, individual mobility services should be offered for selective use impartially, and both integrated and subscription products should be introduced.

To build and operate the K-MaaS platform, a settlement system that integrates private and public transportation must be established. Securing a solution that complies with personal information protection laws is essential, and it is necessary to provide optimal routes and modes of transport tailored to individual needs. Advanced capabilities for constructing and operating MaaS platforms must be developed to align with the transportation policies of the government and local authorities. Enforced participation in MaaS for public transportation(such as buses, subways, and Korea Train eXpress), financial support for transfer discounts, and a legal and institutional foundation must be established. The need for these services must be consistently stated from the perspective of private mobility services.

Citizen-led Living Lab for Smart Mobility

Sejong City living lab for smart mobility

Conceptually, a "living lab" goes beyond a simple space for public participation, allowing residents to participate directly in planning and evaluating policies for their daily lives. Living labs stabilize and advance converged services in urban areas, creating the basis for successful service models. In Sejong City, which was selected as a national pilot smart city, citizens can connect and use various mobility services through LG CNS's MaaS platforms. Relevant services include personal mobility (micromobility) sharing, free-floating vehicle sharing, demand-responsive mobility, automated driving mobility, smart parking, smart intersections, and smart pedestrian crosswalks. In 2022, MOLIT recruited Sejong residents to participate in a living lab demonstration project. In the project, which was piloted in 2022, residents were given access to individual mobility services connected through MaaS platforms and provided suggestions for improvement.
The purpose of this project is to promote service stabilization and advancement by informing service providers of the problems discovered through the direct experiences of citizens and to verify user acceptance and satisfaction of smart mobility services to be introduced to the Sejong National Pilot Smart City.

Composition of citizen participants in living lab

To recruit residents to participate in Living Lab for Smart Mobility, MOLIT had a promotion through various online and offline channels in April and May 2022. A total of 106 residents applied to participated in the Living Lab, and recruitment took place over a period of approximately two months. All residents who applied were selected as participants. Their demographic characteristics were as follows:

- Gender
  - · 60 men and 41 women
  - · 5 people who did not disclose their gender
- Age group
  - · One person in their teens, 15 in their 20s, 15 in their 30s, 33 in their 40s, 14 in their 50s, and 10 in their 60s or older
  - · 18 people did not disclose their age group

Prior to the living lab demonstration of smart mobility, participants were given an orientation course and three workshops to help them understand the project. During the workshops, diverse opinions on transportation problems in Sejong City were collected and training on how to use several new mobility services, including MaaS apps, was provided.

Smart mobility living lab demonstration

For a set period of time, citizen participants recruited in the manner described above had access to the smart mobility pilot services established in Sejong Living Area 1 shown in Figure 4. Their field experience was intended to reveal the need for actual services in a setting identical to an actual service operation environment.

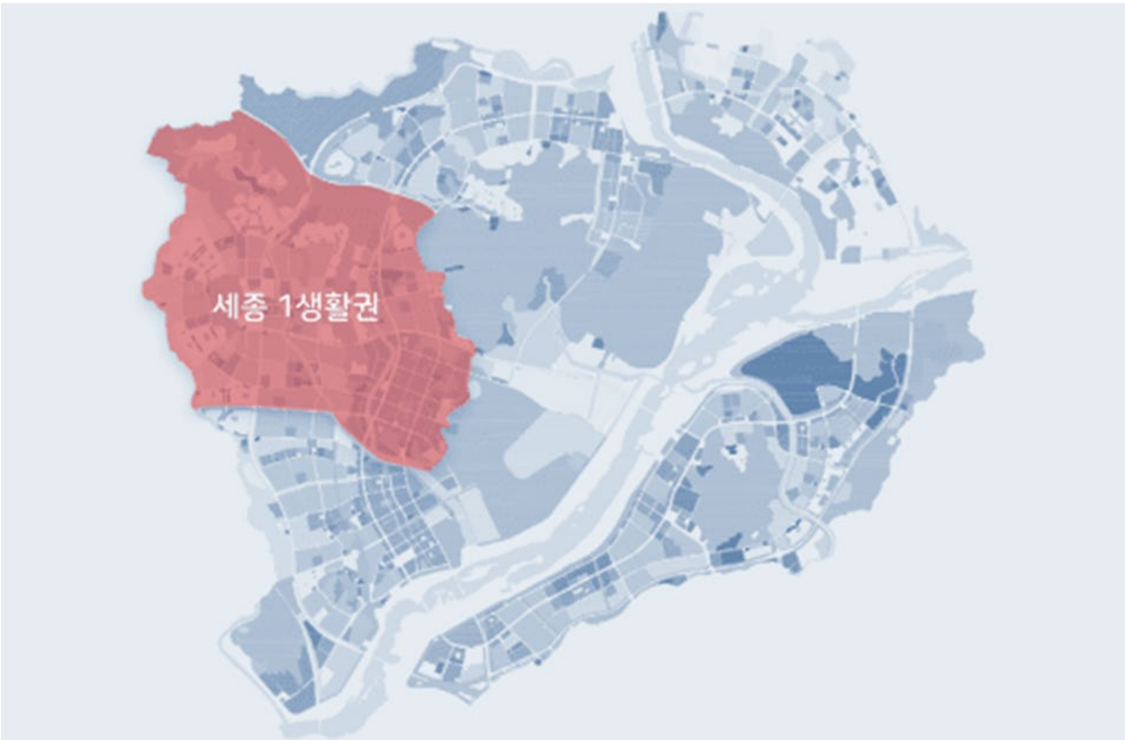


Figure 4. Experience zone for smart mobility pilot services (Sejong Living Area 1) [Source: Sejong Smart City Living Lab for Smart Mobility (https://portal.sejongsmartcity.kr/living-lab/aboutbusiness)]

The five mobility services used in the living lab demonstration are listed in Table 3 below. The demonstration did not include smart parking, intersection, or pedestrian crosswalk services, which were still under development at the time.

Table 2 *Composition of mobility services in Sejong Living Area 1 in 2022*

Classification		Description
Personal mobility (PM) sharing service	Number of units operated	· PM: 600 units (all introduced from existing operation services)
	Places introduced	· Charging stations: Two places (ten parking spaces per place) · Free-floating: Entire Living Area 1 in Sejong City
Car-sharing service	Number of units operated	· Free-floating: 2 units
	Places and parking spaces introduced	· Station-typed free-floating zone: 13 zones · Inter-city bus terminal : 2 parking spaces
Automated mobility service	Station	· Station: 15 stations
	Extension	· 5.1 km
	Garage	· Lake Park Parking Lot 2
	Number of units operated	· Automated shuttles : Two units
Demand-responsive mobility service	Number of units operated	· 2 units
	Station	· 54 stations in Sejong City Living Area 1
MaaS service	Means of connection	· Inside Sejong City Living Area 1: Smart mobility (personal mobility, car sharing, automated vehicles, demand-responsive mobility, etc.) · Outside Sejong City Living Area 1: Existing services including personal mobility and shared vehicles

A MaaS platform app for Sejong Smart City was distributed to citizen participants to allow them to access the services. Participants used the app to secure demand-responsive shuttles, automated shuttles, personal mobility(shared electric bicycles), and free-floating car-sharing services in the way they wanted. The 67 citizen participants involved in the experience used the app freely and accessed the services in their daily lives for three days in November 2022.
All citizen participants used two or more mobility services with the MaaS app and completed an experience survey.

Based on a survey of 67 citizen participants, 20(30%) were very satisfied;

22(33%) were satisfied; 16(24%) were neutral; 7(10%) were dissatisfied; and 2(3%) were very dissatisfied. The average satisfaction level of the participants was 3.76 out of 5. Of the four mobility services, excluding the MaaS app, the service with the highest level of satisfaction was demand-responsive shuttles(25 people; 37.3%), followed by automated shuttles (23 people; 34.3%), shared bicycles(17 people; 25.4%), and car-sharing services(2 people; 3%).

The results of this living lab demonstration are encouraging, considering that the services in Sejong City were provided in a pilot operation environment that had not yet been completed. This suggests the importance of service quality itself, even though the services in question were amazing and the citizens were experiencing them for the first time, including MaaS and automated mobility services.
Therefore, if service quality continues to improve and complete services are provided in the future, user satisfaction with and social acceptance of smart mobility services are likely to increase.

Conclusion

To implement public transportation-centered MaaS, passenger transport operators, MaaS platform operators, and private mobility operators must transition from competitive to cooperative relationships. To address the diverse service demands of various consumers and embrace innovative business models, it is necessary to identify profit models based on the data collected through MaaS platforms. These profits must be reinvested to preserve the public orientation of the MaaS industry.

To ensure the sustainability of K-MaaS, policy transition and support are required to introduce smart technology into existing public transportation systems. Operators of bus routes with low utilization rates must consider converting them to demand-responsive services and consider the introduction of self-driving minibuses to ensure profitability. In this process, it is necessary to consider ways to prioritize and support transportation business rights for existing bus operators to reduce their opposition and improve operational efficiency.

Taxis and personal mobility are consumer-centered and require the following: 1) drastic regulatory reform; 2) infrastructure support, such as PM-only roads and charging spaces; 3) introduction of a flexible rate system based on supply and demand; 4) establishment of exit strategies for elderly taxi drivers; and 5) support measures for innovative sharing models limited to times when supply and demand are mismatched, such as late at night. Until the era of self-driving taxis arrives, in-depth discussion of the measures supporting the development of the taxi industry of the future should continue.

To introduce K-MaaS successfully, financial support focused on passenger transport operators should be expanded to include transfer discounts for public and private transportation, and products based on the unlimited use of public transportation should be discussed. Therefore, local governments must establish a legal basis for expanding the scope of financial support and quickly introduce a carbon tax on passenger vehicles. MaaS platform operators and individual private mobility providers are expected to fulfill their social obligation to promote public transportation and reduce passenger vehicles through contributions and profit-sharing.

LG CNS will do its best to build a MaaS platform centered on public transportation to provide freedom of movement and economy to citizens and to provide continuous sales channels to private mobility operators.

Expectations for the completion of the K-MaaS platform are high. This will be accomplished by opening the API of all mobility operators participating in MaaS to increase the private MaaS platform participation rate and the composition and integrated settlement of subscription products that can be used for both public and private transportation.

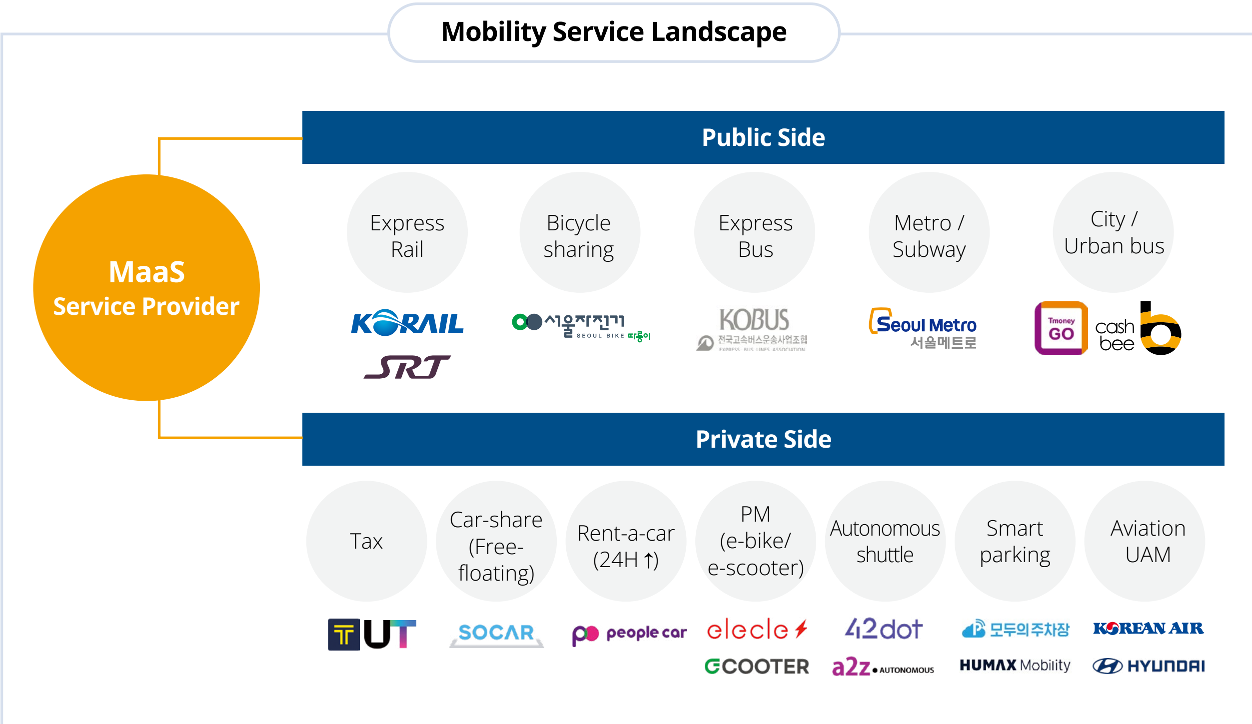


Figure 5. Mobility service landscape

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Socioeconomic Impacts of Mobility Transformation

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Introduction

Recently, the automobile industry is changing rapidly due to the development of IT, changes in regulations and policies, and social demands. As anxiety over the climate crisis rises, the population is becoming more concentrated due to the megacity phenomenon. Meanwhile, the concept of the sharing economy is spreading, and the perceptions of cars are changing. The development of information and communication technology and secondary battery technology, due to digital transformation, has caused changes in the production systems and products of the automobile industry.

Additionally, as economic growth stagnates, governments worldwide are competing fiercely to build a new industrial ecosystem by responding to changes in the automobile industry, which will have a large ripple effect.

Changes in the automobile industry resulting from technological innovations can be organized into four themes: Connected, Autonomous, Shared & Service, and Electric(CASE).

New technologies are making it possible for internal combustion engine vehicles, which are valuable as a means of transportation, to be connected by communication and to use electricity as a power source to drive autonomously, thereby spreading their value to mobile spaces.

Impact of the Mobility Transformation on the Automobile industry

KONRAD ADENAUER STIFTUNG

KOREA TRANSPORT INSTITUTE

Automobile industry paradigm changes

The paradigm shift in the automobile industry began with the introduction of electrification.

Electrification replaces a vehicle's power source with electrical energy, a change that has been made largely in response to environmental regulations on exhaust gases and carbon dioxide emissions from existing internal combustion engine vehicles. As cars are driven using motors and batteries, the structure of the vehicle becomes simpler and control is achieved through software, making it easier to incorporate connected and automated driving technologies. Connectivity refers to connecting cars to the outside world through cloud technology, the Internet of Things(IoT), and improvements in communication speed. It not only communicates external traffic information and situations between vehicles but also allows cars to function as IoT devices by communicating with the road infrastructure. Sharing refers to the provision of ride-sharing and vehicle-sharing services and the broader change in values from favoring car ownership to sharing. As vehicles are connected to the outside world, and vehicle sharing becomes possible through mobility platforms, the utilization of automobiles is maximized. Automated driving can be considered the pinnacle of the automobile paradigm shift, encapsulated by CASE.[1]

1 When Germany's Daimler announced its mid- to long-term strategy in 2016, it defined the next-generation automobile trends as Connected, Autonomous, Shared, and Electric, abbreviating it as CASE.

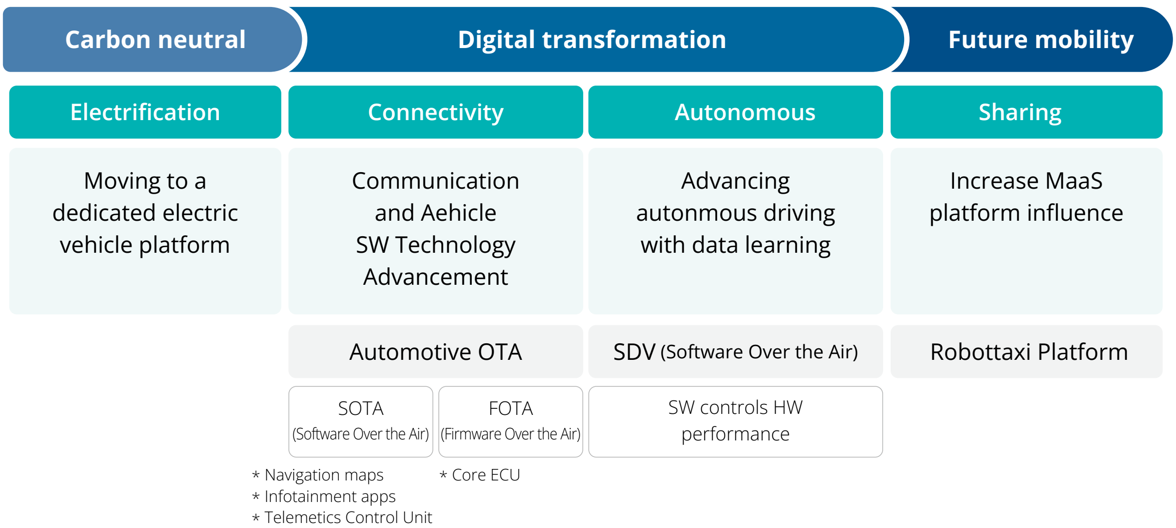


Fig 3-1. Automobile industry paradigm changes and progress paths

This technology replaces the driver, and controls the vehicle by recognizing traffic situations and making decisions independently.
It drives itself by acquiring and utilizing information through connections with the outside and utilizes the vehicle's electrical energy to power the software required to process enormous amounts of information and to drive autonomously.
The addition of technology can expand the usability of shared services.

Meanwhile, the paradigm shift in the automobile industry is expected to unfold over time, as the relevant technology is developed.
With the spread of electrification prompted by environmental regulations and the connectivity progress due to vehicle infotainment; vehicle software applications will increase, and sharing through mobility platforms will begin in earnest.
Ultimately, when automated driving is fully embraced in combination with connectivity, the influence of Mobility as a Service(MaaS) in the automobile industry is expected to increase, changing the nature of the industry from manufacturing to services.

Industrial structure changes and impacts due to progress in mobility

Industrial paradigm shifts are changing the value of the automobile industry. Automobile companies have thus far realized profits by providing cars with good performance that satisfy consumers. However, as the concept of mobility expands and changes to providing transportation services, innovation in business models will be required. Mobility is generally understood as the means for people to move and refers to all means of transportation, including cars, bicycles, trains, and airplanes. In addition, mobility includes services that provide transportation. The existing automobile industry has been limited to forward and backward industries related to manufacturing products called "cars." Recently, however, the CASE concept has been applied to the automobile industry, and products have expanded from ultra-small mobility to aviation, such as Urban Air Mobility(UAM).

Mobility services, such as car-sharing and scooter-sharing, will evolve into various forms depending on the purpose and method of people's travel demands. It has broadened its scope to incorporate logistics and intelligent transportation systems associated with automated driving. Hence, it is referred to as the "mobility industry."

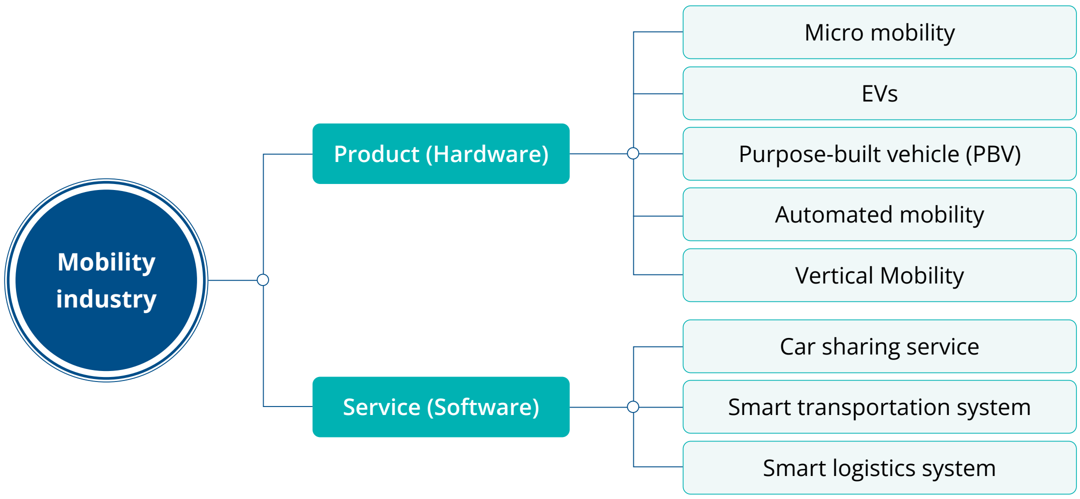


Fig 3-2. Mobility industry scope and divisions

Source: Ministry of Land, Infrastructure and Transport (2022) reorganizes the Korea Institute for Industrial Economics and Trade (KIET).

Owing to the industrial paradigm shift, mobility products are changing from existing internal combustion engine vehicles to electric-powered vehicles. As the core functions of the new vehicles are controlled by software, a new concept called software-defined vehicles(SDVs) has emerged. In addition, the scope of mobility is expanding from land to air with the advent of UAM, which is a means of boarding passengers and moving them by air rather than on the ground using electric power. These changes in products and technologies have also altered manufacturing systems.

Meanwhile, in a situation in which the boundaries between existing industries, new industries, and each field of mobility are becoming blurred, innovative business models are being created through convergence, and the automobile industry ecosystem is expanding as a result. The current value chain structure in the automobile industry is divided into vehicle design and development; parts; system modules; automobile assembly(production); marketing and distribution; and aftersales management. In general, product planning, sales, and after-sales services are carried out by automakers, but collaboration with parts and materials companies starts from product planning. Research

and development is carried out by automakers and parts manufacturers, and parts procurement is carried out by parts companies with a multi-tier structure comprised of the first, second, and third tiers. Distribution and after-sales services are important in the entire automobile industry and provide a lot of employment, but they are mainly done through outsourcing.
Marketing and sales vary depending on the company, but South Korean companies accomplish these tasks in-house rather than using outsourcing. The existing automotive value chain focuses on facilitating the timely procurement of parts for production and increasing efficiency to reduce costs. The transition to the mobility industry is changing the entire automobile industry value chain, as companies in the electrical/electronics, communications, and software fields are now participating in the industry with the advent of electric vehicles and the introduction of automated driving systems. In particular, changes in related industries are expected because the value chains of major parts and production methods differ from those of existing internal combustion engine vehicles. In the case of electric vehicles, the barrier to market entry is low because of the small number of parts, allowing various companies to enter the business. The importance of individual parts companies has expanded relative to companies producing finished vehicle platforms, forming a new value chain.

The change in the value chain as it transitions from producing combustion engines to electric engines includes a new process called charging. Electric charging infrastructure is necessary for electric vehicle operation, and charger production and charging services are required accordingly. Although there are differences in the procurement process for each company, they are expected to shift to partnerships in the form of horizontal specialization and procurement forms based on modularization.

Accordingly, the automobile parts industry is shifting its focus from machine-based internal combustion engine-related parts to electric power-related and automated driving-related parts. The industries producing electric vehicle parts, such as batteries and motors, and electronic parts, such as sensors and software, are expanding. To take the lead in these markets, large global parts companies, electronic parts

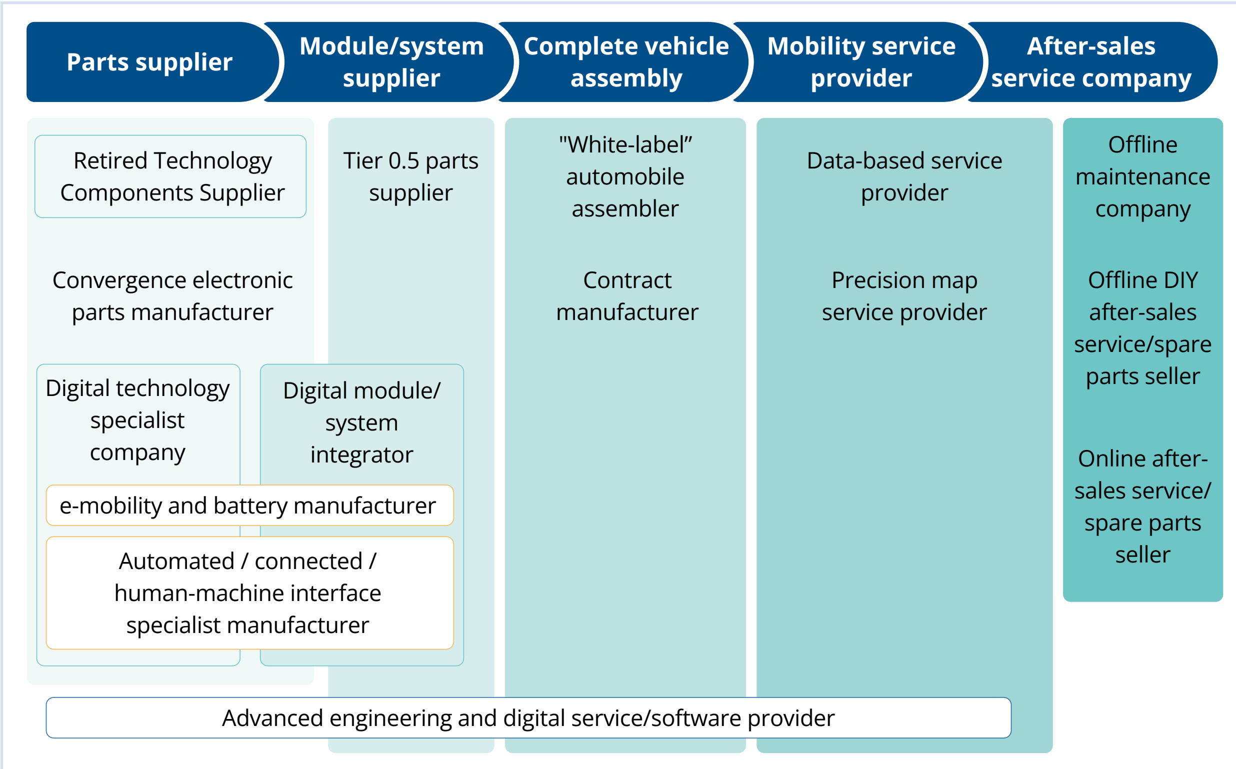


Fig 3-3. Composition of the mobility industry value chain

Source: Korea International Trade Association requoted from Sustained-Quality (2019)

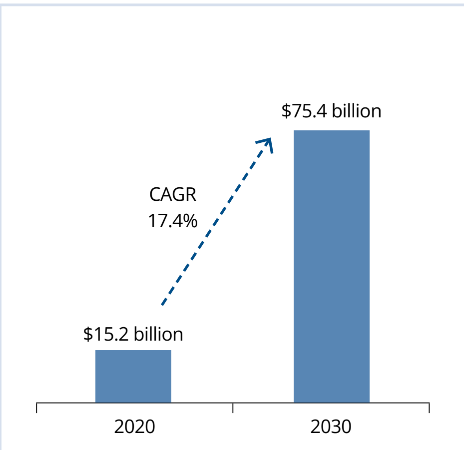
companies, and software companies have entered the automobile industry using their own technology. Existing global parts companies, such as Bosch and Continental, are leading innovation and developing proprietary technologies. As the vertical ecosystem centered on automakers is expected to be reorganized into an open horizontal ecosystem, parts companies with relevant technologies are expected to secure leadership in their relationships with automakers.

With the increase in the number of electric-powered vehicles, systems that supply electric power are installed in vehicles, expanding the range of use of vehicle-integrated control software and vehicle operating systems(OS) that require electric energy. The data collected by the vehicles can be analyzed using software. It is expected that the distribution of SDVs will provide a variety of vehicle-based services. In the case of electrification, the impact on the automobile parts industry changes from an internal combustion engine to an electric vehicle. By contrast to parts related to driving, smartization of the communication system allows the vehicle to recognize traffic patterns, judge options, and execute maneuvers in the process of providing mobility services. The impact of the smartization process on the automobile parts industry is expected to increase. As technology becomes more advanced, electrical components require higher reliability to ensure safe vehicle operation. Because the barriers to entry are high, dependence on a small number of companies, the so-called big tech companies, increases.

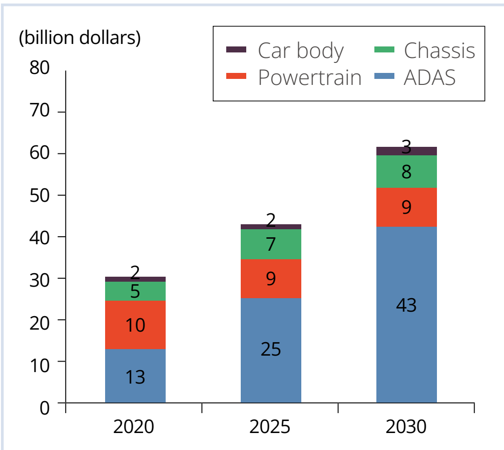
Companies in other industries, including IT, are entering the automobile industry by acquiring technologically advanced parts companies, reducing the cost and time required for research and development. First, automated driving companies can be divided into those supplying software and those supplying hardware. Software companies include full-stack suppliers that control the overall OS and software for automated driving along with individual suppliers in areas such as positioning, mapping, and recognition. Full-stack suppliers are subsidiaries of large IT companies or existing automakers, such as Waymo, Aurora, Cruise, and ZOOX, while individual software suppliers are mainly startups.

Representative hardware components for automated driving include sensors for recognition, such as cameras, lidar, and radar, and automotive semiconductors for processing. Most of the companies producing these components used to supply parts for IT devices; explosive growth is expected in the future due to changes in the industrial paradigm. They are entering the automobile industry through strategic partnerships and mergers, and acquisitions(M&A) with existing companies.

Table 1 *Changes in the size of the automated driving technology and automotive sensor markets*



Source: Morningstar



Source: McKinsey

Transportation services—including rental cars, taxis, and public transport operating on fixed schedules and routes—are evolving to embrace the concept of MaaS with the advent of connectivity and SDVs.
Currently, the range of services is broadening from early stage vehicle-sharing, such as car sharing, ride-hailing, and ride-sharing segmented on an hourly basis, to include domains related to ultra-short-distance travel and object transportation, such as micromobility and delivery. A hallmark of the initial phase in the MaaS transition is the shift from fixed routes and schedules to on-demand services, which allows consumers to use transportation services when and how they prefer them. In the future, mobility services will further expand to cover entire travel distances, leveraging diverse mobility options, such as micromobility and vertical mobility, including UAM, through mobility platforms. These platforms enable real-time connections between consumers and providers for seamless mobility services, offering information and optimizing transportation linkages through integrated algorithms and payment methods. Uber, Lyft, Didi Chuxing, and Grab are examples of mobility platform companies entering the automotive industry ecosystem and thriving, with ride-hailing as their initial model.

The paradigm shift in the automobile industry, epitomized by CASE, has also altered the industry's competitive advantage structure. Historically, the sector consisted mostly of mechanical parts, and new entries were challenging due to economies of scale, elevated technological barriers, and relationships with consumer companies. However, as the mobility transition unfolds, modularization, electronics, and the horizontal division of labor are becoming significant competitive factors. These developments are reducing barriers to entry and laying the groundwork for the emergence of new automakers, such as Tesla and BYD.
With the emergence of diverse consumer classes, the market is evolving into one that is buyer centered. The growing influence of social media has amplified its impact on individual buyers. An increase in suppliers is expanding consumer choices. Additionally, the rise of mobility platform companies is expected to boost sales of large fleets, thereby enhancing buyers' negotiating power. Suppliers' bargaining power is intensifying due to the incorporation of numerous IT technologies, elevating the role of major component companies within the supply chain. Concurrently, IT companies, which were previously peripheral to the supply chain, are

penetrating the automotive industry, heightening the significance and exclusivity of these components. This reduces the relative advantage and negotiating leverage of automakers over shares of value-added. In summary, competition within the automobile industry is escalating and is marked by heightened rivalries among various actors in different domains. This includes geopolitical competition between nations, such as the United States, Germany, Japan, and China; intercorporate competition; and competition involving major tech companies.

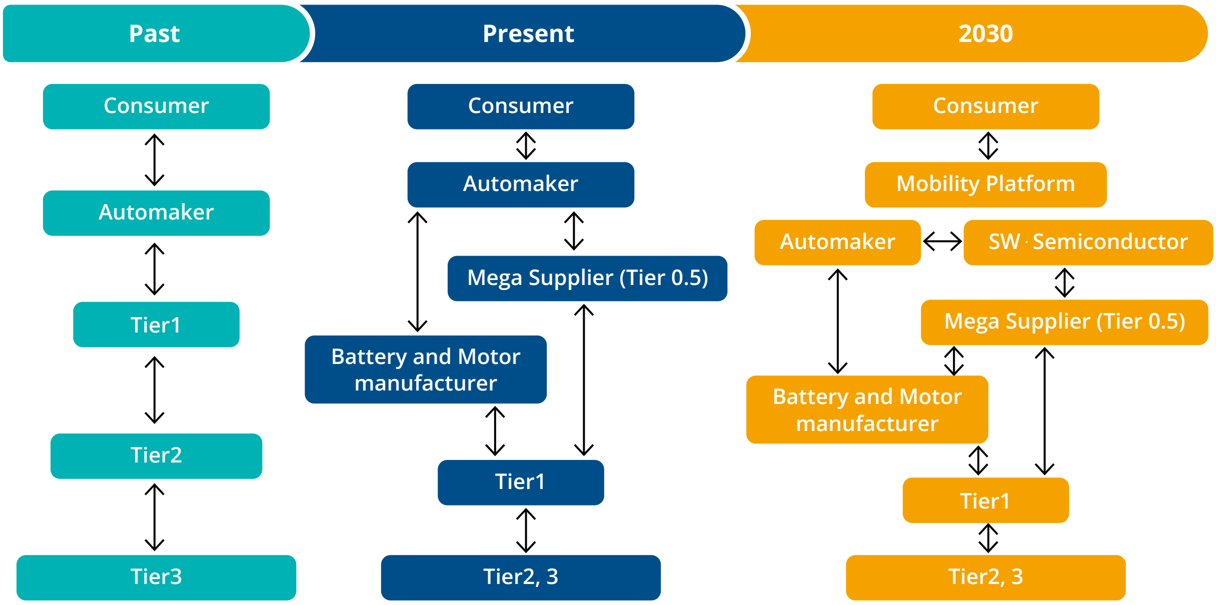


Fig 3-4. Changes in the transaction structure within an industry due to mobility transformation.

As competition intensifies among the participants, crucial decisions regarding positioning and profit models will gain prominence. In the future, the collaborative structure in the automobile industry is expected to shift from the existing value network configuration to a model in which automakers select and assemble individual products. Consequently, the determination of vehicle functionality and usage is transitioning from being hardware-centric to predominantly influenced by software, allowing automakers to tailor vehicles to meet the nuanced needs of individual consumers or mobility platforms. Both the automobile and IT industries require the formulation of business models and market preemption strategies that consider the business scope and revenue-generating mechanisms from the vehicle development phase.

Conclusion

As the automobile industry evolves into a mobility industry, the universal platforms for both hardware and software are broadening. Power sources for automobiles are simplifying, and the production capabilities of contract manufacturers are advancing, thereby lowering barriers to entry for the automobile industry. Consequently, competition is becoming borderless and intensifying, with the participation of companies from various sectors. In terms of automated driving, fierce competition exists to gain dominance in vehicle OS production. Given the intrinsic emphasis on safety in automobile products, automotive companies have adopted conservative stances. By contrast, big tech companies and startups, aiming to secure a pioneering position in this field, are pursuing more radical approaches. As the proliferation of SDVs accentuates the importance of vehicle OS differentiation, vehicle upgrades through over the air(OTA) are emerging as a pivotal competitive advantage.
This has led to an evolving competition between newcomers such as Tesla and established automakers. Existing automakers are not only competing among themselves but are also collaborating with big tech companies possessing advanced software technology to counterbalance the influence of new entrants.

As an industry's value-chain fragments and technologies intersect, the release of innovative technologies and products alters the market and competitive landscape, highlighting the limitations of focusing solely on hardware for sustainable growth. Although technology retains its importance in the automobile industry, the sector's expansion into mobility services necessitates pioneering business models, thereby elevating the significance of software, communication, and infrastructure. Given this evolution, automobile manufacturers, primary and secondary companies, and new entrants must reassess their positions and core competencies in the automotive industry's value chain.

As advancements in mobility industry technology persist, substantial alterations in associated industries are imperative, necessitating M&As for the convergence and incorporation of technology. Traditional internal combustion engine component companies, which are anticipated to experience demand reductions due to these technological shifts, need to categorize their business into core and non-core sectors, acquire or incorporate suitable innovative capabilities reflective of the evolving industrial framework, and extend component companies to attain economies of scale. M&As are essential for these adaptations. Furthermore, to secure competitiveness in newly emerging sectors in which technologies converge and are applied, active M&A engagement with diverse industries is crucial. As the mobility industry evolves, collaborations between companies need to be more organic and holistic, in contrast to previous segmented approaches. To achieve this, existing companies and newcomers in the automobile industry must pursue more strategic collaborative efforts.

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