EIT InnoEnergy
Knowledge Innovation Community

Energizing mobility's future

Roadmap Energy for Transport and Mobility (ETM)

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Energizing mobility's future

Introduction

How the climate crisis shapes the future of mobility

The world is in a crisis – a climate crisis. From wildfires in California, floods in India and Bangladesh to heat waves in Europe (all happened in 2019) – at almost 1° C over pre-industrial temperature levels, mankind already experiences what life in a warmer climate will mean.

With the Paris accord, many countries aimed to hold the increase of global temperatures to well below 1.5° or 2° C above pre-industrial levels. To reach the 2° C goal, global carbon emissions needed to peak by 2021. To reach the 1.5° C goal, this would need to happen in 2020 already. However, we are still far away from reaching those levels. Following current trends, global carbon emissions will only fall by about 20% by 2050 – but 66% are required to reach 1.5° C.

Mobility and transport make up for 25% of all man-made CO2 emissions today – and are one of the few sectors in which emissions still grow. This is not due to lacking improvements in vehicle technology, transport infrastructure, and the energy systems – but mainly due to a still growing demand for mobility for both people and goods.

By 2050, the passenger km traveled will grow by a factor of nearly 3 – from 44 trillion in 2015/16 to 120 to 130 trillion in 2050. Freight tons will increase more than threefold from 108 trillion to 340 to 360 trillion. And energy demand and hence CO2 emissions? Innovation already identified today – in mobility and transport, could help curb demand and emissions to about 7,000 million tons in 2050 – lower than today's 7,800 tons. But this is far from enough.

Besides the sheer need for decarbonization, there are also other factors driving the revolution in mobility and transport. First, a growing world population and increasing urbanization change how people and goods move. By 2050, almost 10 billion people will live on earth (nearly 2.5 billion more people than what we have today) – 70% of them in cities. The global economy is projected to double in size by about 2042. Emerging economies will drive 80% of this growth.

Second, the good news is that we see more and more bold regulatory actions in certain world regions. Europe aims to reduce CO2 emissions from new passenger cars from 130 g/km in 2015 to about 95 g/km in 2030. Cities begin to play a major role in the future of mobility – becoming orchestrators for different mobility in urban environments. In addition to defined regulations, organizations are also making new commitments for addressing climate change. The International Maritime Organization agreed to reduce total annual GHG emissions from shipping by at least 50% by 2050 (compared to 2008).

Third, in order to drive this disruption, we need breakthroughs in technology which will reshuffle the mobility ecosystem. In road transport it is primarily the so-called four ACES (autonomous driving, connectivity, electrification, and smart mobility) which transform the industry.

Fourth, the stakeholder and value chain for mobility is being challenged and opened. For example, 515 partnerships have been concluded by global automakers since 2010 – including joint ventures, strategic alliances, and acquisitions. One example is the cooperation of Daimler and BMW in autonomous driving and in mobility services; another the cooperation of Volkswagen and Ford on electric vehicles (EVs).

And finally, consumers begin to rethink their mobility behavior. Shared mobility is taking off: 25% of respondents state that their use of mobility services is the reason why they do not own a car. And: the total number of micromobility trips rose from 35 million in 2017 to 84 million in 2018.

In short: mobility will change tremendously, and it needs to – otherwise mankind will not be able to solve the climate crisis. In the next chapter, we describe in more detail what role InnoEnergy – together with you – can play in this undertaking.

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InnoEnergy's purpose of investing in Energy for Transport and Mobility (ETM)

InnoEnergy's purpose is to bring the strong European energy, transport and mobility landscape to a new level in sustainable energy use and GHG reductions. With the challenges and needs for action described, we are committed to live up to be the innovative ecosystem that helps drive the disruption in sustainable transport and mobility in Europe. We also build on our strength to successfully create and grow ecosystems in Europe (such as with the European Battery Alliance).

Our focus is to support technology-driven, young, small, and medium-sized companies which are based in Europe but have the potential to reach global impact. To guide our activities, we base our decisions on a concise 3P framework: "planet, people, profitability."

We assess the impact of each of our investments on whether it fosters the sustainable utilization of our planet, improves accessibility and health of people, and creates long-term value. Those are the key considerations for each dimension.

Planet Does the investment opportunity prevent dangerous global warming through lowering emissions, reducing energy demand – hence contributing to climate goals? Does it contribute to a more sustainable use of resources, and especially an efficient use of scarce resources? Does the investment create more livable communities and green spaces – especially in cities? The concrete KPIs behind this dimension may include the reduction of GHG emissions measured in ppm or gram, the reduction of total energy demand in GW or GWh, or physical space improved (measured in m2).

People Does the investment support ethical standards and proliferates safe, healthy, and efficient transport of people and goods? Does it expand convenient, flexible, and affordable solutions and promote a shift to more sustainable mode of transport? Does it improve a more secure energy supply? And does the investment help reduce traffic and the time spent in traffic? KPIs for this dimension are air quality improvements, average idle time in transport, typical total commuting times, or a shift towards more sustainable modes of transport.

Profitability Does the investment support a proven product market fit and does it have enough attraction and market pull with consumers? Does it improve the economics of the energy system for transport and mobility? Does InnoEnergy have the potential to significantly accelerate commercialization and scaling of selected companies? Is the market entry clear and the associated stakeholders able to be convinced of the solution? Our key KPIs for this dimension will be revenues, time to market, and return on investment.

The ETM focus areas

Overview

Against the background of the climate crisis and changing mobility patterns we assessed the whole playing field along all modes of transport and the mobility value chain. For the modes of transport, the scope went from small to big: walking/cycling, two-/three-wheelers and micromobility, cars and shuttles, buses, commercial vehicles, rail, marine, planes, urban aerial mobility and construction/utility, and off-road vehicles. We also looked at the whole value chain: from vehicle concepts and technologies (e.g., zero-emission drivetrain), and enabling technologies such as charging infrastructure to new mobility services (e.g., shared mobility and aggregator platforms).

Along this value chain, cars, shuttles, and commercial vehicles have and will continue to have the greatest global energy demand. As a consequence, they also contribute the greater share of CO2: road transport with more than 70% of total CO2 emission and 65% of the energy demand from all transport.

Along those priorities, we concentrate our investments on five focus areas to support and strengthen the European transport and mobility landscape. The majority of these focus areas cover multiple modes of transport to ensure strong impact on energy and emissions.

The focus areas are:

1. **Zero-emission drivetrain,** including, e.g., advanced battery technology with higher energy density for passenger cars; hydrogen as a carrier for fuel cells or internal combustion engine; and e-drive systems.

   The technology in this focus area is already market-fit and has a direct impact on GHG emissions, raw material use, and energy efficiency. As a second order effect it thus also improves public health and the affordability of transport.

2. **Autonomous driving technology,** including products like advanced software, sensors, and other electronics, e.g., LIDAR systems, including algorithms for trucks as all-in-one solution.

   In this focus area we see strong business cases which are, however, restrained by long-term uncertainty. An optimized movement of vehicles could improve several dimensions, though: lower emissions, safer traffic, as well as better affordability and availability for people. Robotaxis, (pooled and nonpooled) could account for up to 20% of vehicles on the road in European cities.

3. **Innovative transport concepts,** including offers that make the last mile for people (micromobility) or goods more efficient, or allowing for purpose-optimized concepts like, e.g., new rolling e-chassis could. This focus area could also entail vehicle concepts which take an enabler role for primary planet and people targets of InnoEnergy by significantly improving the uptake and the business case across technologies.

4. **Energy provision infrastructure,** including sustainable and efficient EV charging stations and or hydrogen infrastructure.

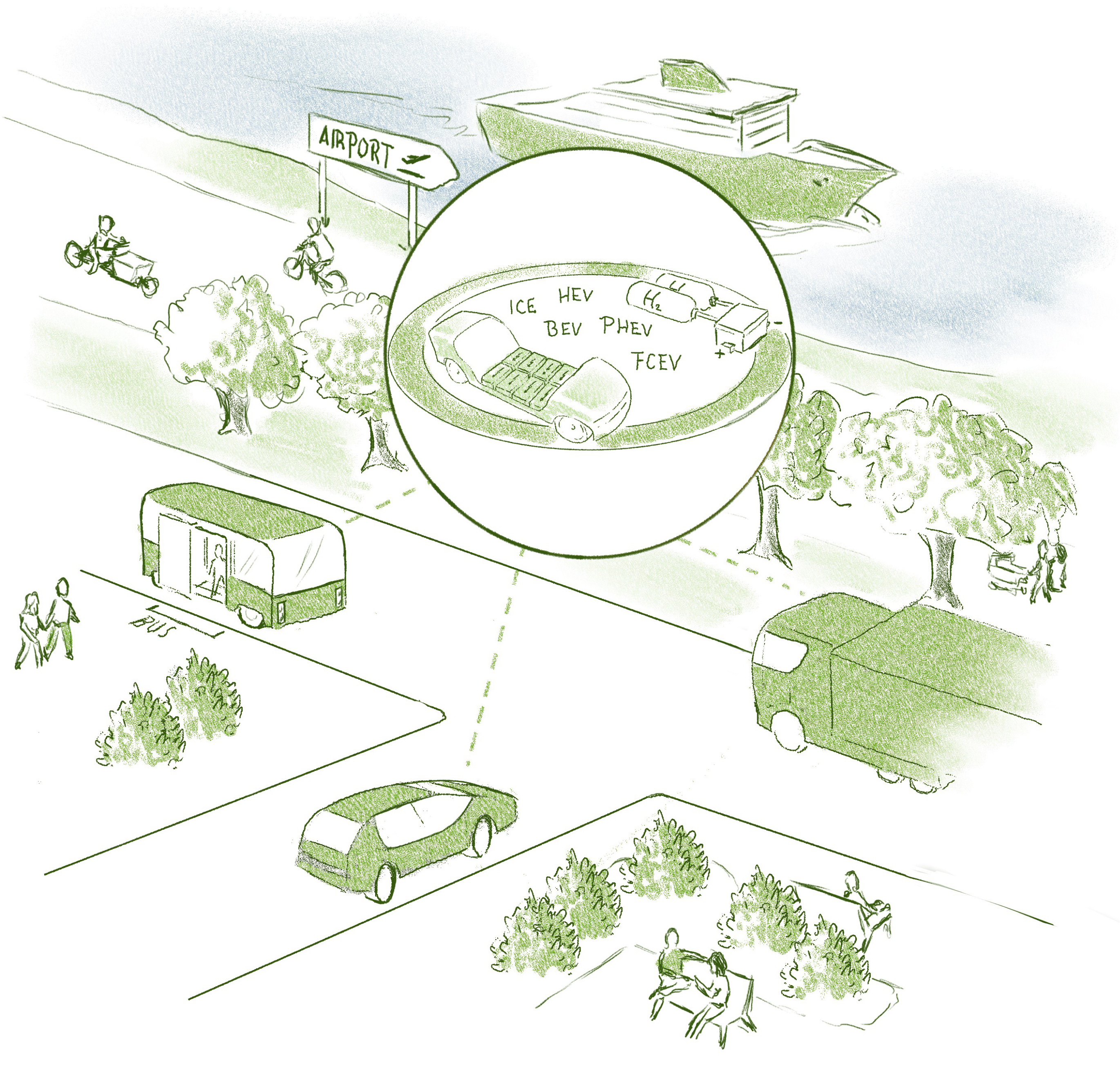
   A better infrastructure – which is thoughtfully integrated with other sectors, will enable sustainable transport and mobility in Europe – it also impacts space and availability with the rollout starting already today.

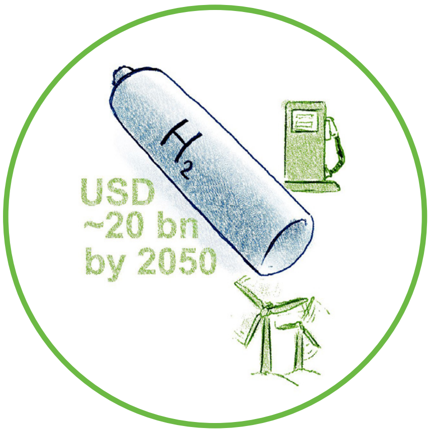
5. **Mode-shifting new mobility services,** including improved algorithm and route calculation for shuttle services to improve the operations – or mode aggregator service provisions. For the end customer, value shall be created by seamless access, real-time information, payment, and services.

   Optimizing the use of transport modes can have strong implications for all 3P targets – the respective business models are already gaining traction today. The European mobility-as-a-service (MaaS) commission market is estimated to be worth EUR 180 to 380 million by 2023.

In all these focus areas we see tremendous impact based on our 3P framework and hence will describe each in more detail in the following chapters.

1 Zero-emission drivetrains





The electrification of the drivetrain gained significant momentum over the last 12 months. Two factors drive that rapid development. First, the EU has tightened emission regulations – all OEMs have to meet the strict 95 g CO2/km target with their whole as of 2021. As a consequence, they have announced to bring more than 300 purely electric models to the market by 2025. This regulatory push is accompanied by a customer pull – more and more people consider buying an electric car; or even riding electrified alternatives such as e-bikes, e-mopeds, or e-scooters. And we may start to see a mid-term effect on the residual value of ICEs.

New battery systems – impact across 3P principles

Planet

Energy demand

The production process for batteries is energy- and resource-intensive (resulting in 182 Mt CO2e emitted by 2030). However, EVs recover this disadvantage after only 24,000 km (from a CO2e perspective) due to their higher efficiency (~ 60% of electrical energy vs. 20% of fuel converted to energy for ICE).

Emissions

The total global battery production footprint is expected to increase from 24 Mt CO2e (2018) to 182 Mt CO2e (2030) – mainly due to higher number of EVs. But in operation, EVs currently emit 30 to 60% fewer emissions – depending on energy mix, helping reduce CO2 emissions overall.

People

Accessibility

In the mid term, the lower cost of BEVs through a professionalized and well-functioning battery supply chain could enable more customers to purchase BEVs/PHEVs compared to internal combustion engine cars. This also provides customers access to future zero-emission zones. Follow-through effects through, e.g., the reuse of batteries could provide 600 million people with access to electricity. In addition, battery recycling for reuse in vehicles is strongly emerging and developing traction.

Health

EVs would have a significant positive contribution to air quality levels in inner cities. 97% of cities in low- or middle-income countries do not meet WHO air quality guidelines today. EVs emit 19 to 60% less CO2 during their lifetime and no other pollutants in operation (e.g., NOx) – and could hence be an important lever to improve public health.

Profitability

Market demand

The global battery demand is expected to scale 19x by 2030 (up to ~ 2,600 GWh in the base case), with demand for more than 320 GWh in Europe by 2030. Compared to that, supply in 2018 was only 17 GWh for BEVs alone.

Technology

Lithium-ion batteries are currently the industry's main focus for drivetrains across modes. Significant research is yet ongoing into, e.g., different cathode materials or solid-state batteries to address resource scarcity, toxicity, and performance. Whatever the cell chemistry, battery management systems and software are also increasingly important drivers along the tech stack.

Business model/GTM

Currently players primarily focus on mining/refining, battery cell/component/pack production and battery sales. This opens up opportunities for, e.g., leasing models or supporting services related to certification/battery health or reuse/recycling. This is especially important as OEMs are mandated to take back batteries.

Future structure/competition

Scale becomes increasingly important for cell production with more than 250 GWh announced in Europe for battery supply – with an increasing number of OEM/(new) Tier-1 partnerships (such as between VW/Northvolt, BMW/CATL). Yet there are still many smaller players with greater investment opportunity, e.g., in R&D (collaboration with universities) and recycling/reuse.

Value chain and investment opportunities

While a fully-fledged supply chain for batteries is still being developed, some interesting areas for investment can already be identified. From harvesting and refining raw materials, manufacturing battery cells, modules and electronics through assembling and packing pack (including software and integration with machine) to using battery packs as well as recycling or reusing cells – multiple investment opportunities exist. The main focus of this thematic field is on the assembly and packing, as well as the use, integration, and optimization in a vehicle. The other areas are primarily covered within the thematic field Energy Storage at InnoEnergy.

Throughout the battery system value chain one focus should be on driving battery technology improvements (of both existing and new technologies) – aiming at longer battery lifetime and higher durability.

Especially for smaller vehicles (e.g., e-scooters), improving the battery systems itself – e.g., by making them interchangeable – is an important step towards better sustainability. In use, there is also room for improvement for better battery management systems (e.g., to extend lifetime); further opportunities lie in providing upcycling or repair services. Finally, new leasing and financing options could support the rollout of batteries into different vehicles types.

Improvement in all steps of the value chain are needed – as the electrification of light vehicles in the EU will require a massive scale-up along the ecosystem. The demand for raw materials will increase 17-fold until 2030. And the battery will play a significant role in the overall vehicle value chain.

While in today's ICEs the powertrain constitutes some 25% of the overall value, this number will increase to 60% in a BEV – with the battery being by far the largest factor (76% of value in BEV powertrain, almost 50% of value of the entire vehicle). Improvement in battery costs hence translate into sinking vehicle prices – and indeed lithium-ion battery costs are coming down faster than expected. Some players claim to reach cost parity with ICEs as early as 2021.

While Europe has been strong in the ICE powertrain value chain, Asia dominates the battery value chain. Currently battery production is centered on South Korea, Japan, and China – with China accelerating. The top ten players – all Asian – take around 90% of the overall market share. By 2025, the overall battery manufacturing capacity is expected to reach 867 GWh, with strong growth in China and Europe.

Hydrogen as a carrier – impact across 3P principles

Planet

Energy demand

Hydrogen production comes with a significant energy footprint – however, hydrogen is an attractive storage option for energy as it can be transported and stored for longer time periods and could therefore be used to store, e.g., unused solar or wind power.

Emissions

Hydrogen could be a significant lever to reduce CO2 emissions given its potential applications in multiple transport modes. Moreover, hydrogen is a less resource-intense technology (e.g., no use of rare materials) – but green or blue hydrogen would be required to truly reduce emissions.

People

Accessibility

The proliferation of fuel cell electric vehicles (FCEV) would give consumers and commercial users a bigger choice; especially for consumers with use patterns that are currently not fully served by BEVs. One of today's advantages of FCEVs is, for example, that FCEVs recharge today at a 15x higher speed than BEVs with fast charging.

Health

Health would be increased due to reduction of CO2 and other particulate emissions when ICEs are replaced with FCEVs. Moreover, there are no negative externalities for, e.g., cobalt mining workers compared to BEV.

Profitability

Market demand

The fueling/charging value pool for hydrogen could reach USD 20 billion net earnings by 2050, with the large scale-up expected only after 2030. However, for some vehicles cost parity with conventional propulsion technology is possible today: for regional trains an FCEV is 55% cheaper vs. diesel, and by 2040 the opex for FCEV trucks is expected to be ~ 80% lower than today.

Technology

The fuel cell technology is generally ready for, e.g., automotive applications and already in use by selected OEMs. Some startups explore hydrogen as a fuel in ICE instead of fuel cells. The key challenge remains to find cheaper solutions for, e.g., transport and storage.

Business model/GTM

Achieving profitability requires significant scaling of the hydrogen ecosystem – as the costs are still prohibitive (e.g., for refueling infrastructure, production plants). This could be achieved by lock-step solutions. In general, a wide range of services and opportunities is available along the value chain.

Future structure/competition

Multiple automotive OEMs (passenger car producers and truck makers) as well as selected startups like Nikola are currently developing FCEVs. We see cooperation between players, e.g., OEMs, to share components.

Value chain and investment opportunities

The value chain for hydrogen as a carrier includes the development and production, the operations and financial services.

As a first step, ETM could support the development of technology advancements in FCESVs or fuel cell buses as well as fuel cells or hydrogen for ICEs are relevant for moving the field forward. Digging deeper, providing specialized FCEV or hydrogen-ICE components (such as pressurized tanks) or developing adjacent hardware such as fuelcell-related technologies for interior heating or cooling can be valuable drivers in the field of hydrogen – just as are efficient operations and services and the right level of financial services for users.

The use case for FCEV is compelling especially for larger vehicles. In this segment FCEVs are expected to become cost competitive to BEVs in 2023 and to ICEs in 2030, as the costs of the fuel cell system will decrease by 55% until then, and even by 70% for the distribution and refueling infrastructure. As an additional plus, FCEVs also have a much shorter refueling time than even fast-charging BEVs – and a bigger range. Compared with synthetic fuels, hydrogen is half as expensive per 100 km and offers 1.7x more range per kWh of electricity used than synthetic fuels.

Beyond road vehicles, hydrogen is a viable alternative for trains. Two hydrogen-powered trains are in operation in Germany today, and 43 more are planned to be deployed by 2023. This is driven by a simple logic: while a diesel train might still be cheaper, the costs to electrify a diesel track are very high – so overall, a hydrogen train is some 55% cheaper than a diesel train.

E-drive systems – impact across 3P principles

Planet

Energy demand

E-drive systems support the proliferation of purpose-built vehicles. These concepts could lower energy consumption due to more specialized design and engineering ("rightsizing") – with the use case at the center. Hence, e-drive systems thus reduce overall transport energy demand.

Emissions

E-drive systems also have an impact on CO2 emissions, as more affordable EVs will replace ICEs. Moreover, those systems address use cases like last-mile delivery which have an impact on emissions (CO2 and particulate) in densely populated areas.

People

Accessibility

More affordable vehicles and a greater variety of form factors enabled by, e.g., e-drive skateboards make EVs more accessible – especially for lower-income households.

Health

E-drive systems could disrupt, e.g., urban delivery services by enabling purpose-built EVs and thereby replace ICEs (with their emissions and pollution). Special-purpose vehicles enabled by e-drive systems can also replace humans in, e.g., specialized or dangerous applications, reducing overall risk.

Profitability

Market demand

Electric vehicles are expected to account for ~ 25 to 35% of vehicle sales by 2030. This will create further demand, with significant market potential for e-drive systems – e.g., due to high number of potential customers (4.5 million Lyft and Uber drivers). The OEM uptake of e-drive systems is set to vary with maturity.

Technology

Depending on target customer and body architecture, the scope for e-drives ranges from e-axles to full body-on-frame skateboards. The technical complexity of e-drives is significantly lower than for ICE platforms. Today, already more than 10 suppliers offer e-axles or drives.

Business model/GTM

Marketwise, there is a risk of commoditization of e-drives which could decrease profitability. One reason is that the entry cost for suppliers and manufacturers is low compared to ICE platforms. On the other hand, there are new potential customers for such systems such as EV OEMs (especially newer/smaller) and mobility service providers (MSPs), e.g., for engineering services or production.

Future structure/competition

There is a significant opportunity to supply new EV OEMs or MSPs, potentially also logistics companies. Hence Tier-1 suppliers develop a wide range of e-drive systems, ranging from e-axles to full e-skateboards, with some OEMs also providing full e-chassis (e.g., VW).

Value chain and investment opportunities

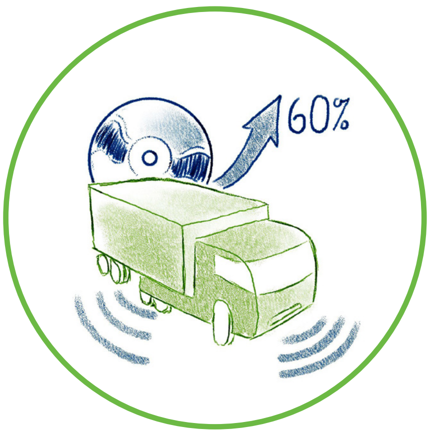
Within the e-drive production system, we again see various investment opportunities – ranging from specialized subcomponents through individual powertrain components to drive system integration as well as testing and vehicle integration.

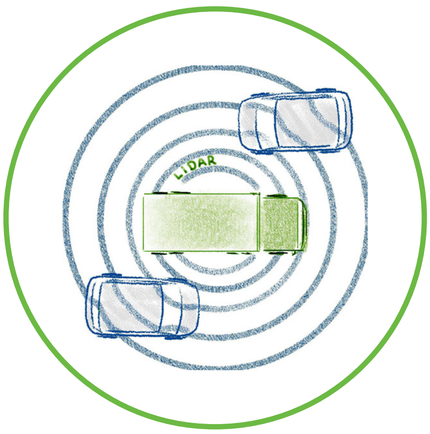
Players could position themselves as third party contractors, providing manufacturing capacity. Within individual powertrain components, ETM could support companies that develop hardware (such as brakes or the steering column). Moving one step further, players could develop full systems like, e.g., the e-skateboard or partial systems such as the thermal management, safety systems, steering, braking system, or the e-axle. In the testing and vehicle integration step, companies could be supported that provide integration, testing, and certifications services; that provide engineering services like thermal management improvement or that deploy leasing concepts or maintenance and engineering service provisions.

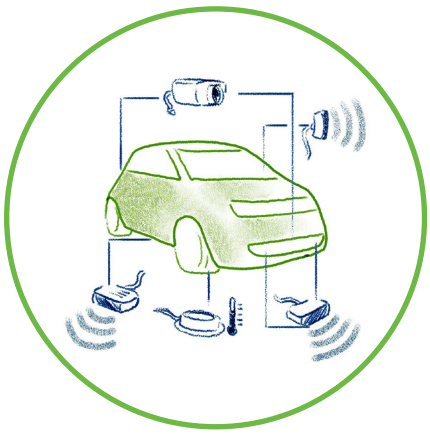
From e-skateboard to rolling e-chassis – flexible and modular e-drive systems offer the possibility to cover a wide range of use cases and could enable fast scaling. Integrated offers in the chassis could revolutionize OEM and supplier collaboration – with faster time to market, a shift in design responsibility and capex distribution, with new architecture solutions, a shift in capabilities and lower barriers to entry. This disruption of the supply chain could result in many different moves from the players: new players could enter the space as new Tier-1 suppliers, Tier-1 suppliers could develop into Tier-0.5 suppliers; and OEMs and Tier-1 suppliers could integrate backward in new areas such as the e-axle (for OEMs) or batteries and electronics (for Tier-1s). For many players this means that their coverage of the value chains will expand. The good news: overall, the powertrain is still set for growth – by about 5% until 2025.

In this newly emerging value chain, some components – especially in the electric drivetrain – will be crucial: given its share of overall vehicle value, the battery cell and the battery pack will constitute an important part of the overall revenue share. Earlier in the supply chain, the inverter, the power distribution unit, the DC/DC converter and the charger will be key. Finally, the overall system integration and the definition of features will be an important aspect of the new supply chain. All those areas can be understood as "control points" – crucial aspects of the chain which will give significant advantage to those players who manage them.

2 Autonomous driving technology







Autonomous driving technologies have the potential to significantly change mobility as we know it – and thus will have a major impact on the future of mobility: they do not only change how people and goods move, but also show tremendous potential for greater efficiency in the overall mobility system – by improving traffic flows, improving idle times, avoiding unnecessary rides (e.g., searching for parking), etc. In turn, this would lower the energy demand and cut GHG emissions. While fully autonomous driving (level 5) is still far out, the upcoming years will bring viable applications in level 2 and level 3 settings.

Autonomous driving technology – impact across 3P principles

Planet

Energy demand

AD reduces the overall energy demand due to primary effects like more efficient driving strategies, less idle time and fewer stops. For trucks, fuel savings and consequently emissions reductions could reach up to 10 to 15%. Moreover, autonomous vehicles could reduce the need for parking spaces, e.g., the US by 5.7 billion m2. There are also secondary effects like lower vehicle production as users move from private vehicles to AVs. Additionally, AD is a key enabler for mode-shifting mobility (e.g., from private cars to roboshuttles).

Emissions

Self-driving technology reduces vehicle CO2 emissions through synchronous driving, optimized routing, fewer traffic jams, which could reduce fuel consumption by up to 25%. Moreover, most AVs will be EVs, helping further reduce emissions. Majority of AVs expected to be EVs, helping to further reduce emissions.

People

Accessibility

AD reduces the cost per mile which supports the mobility transition away from private cars. For users with annual driving distance below 20,000 km, an AD-based car-sharing model is economically attractive. Autonomous driving could also help provide individual mobility to, e.g., elderly and handicapped users.

Health

AD could potentially reduce accidents by more than 90% – as nine out of ten of accidents today are caused by human error. This leads to nearly 1 million hospital days and USD 212 billion per year caused by automotive accidents in the US alone. On top, autonomous vehicles could allow average drivers to free up about ~ 50 minutes per day – which they could use for sleeping, communicating or reading.

Profitability

Market demand

The total potential value for shared autonomous technology in urban areas sums up to USD 1,600 billion annually by 2030 – as much as the spend on defense, globally. By 2030, the sales revenue of level 3 and 4 AD cars may reach USD 2.400 billion. Two-thirds of consumers are willing to switch the brand for better AD features.

Technology

Based on multiple sensor technologies in use, the first level 3 vehicles – with automated highway driving – will have their start of production by 2021. Level 2 entry features will be replaced by superior AD features, the level 3 highway pilot will stay a niche product as it will be quickly replaced by the level 4 highway pilot.

Business model/GTM

Sensors and central control units (CCU) will have the highest revenue pool – and software-centric elements the highest profitability. As a second effect, AD reduces productivity losses (e.g., traffic jams), costs for healthcare systems and infrastructure, and CO2 emission.

Future structure/competition

Leading players form strong partnerships and ecosystems for the development, testing, and deployment of autonomous driving (OEM + X). Clear leaders are emerging at the moment, e.g., Waymo achieving 2x more miles per disengagement (situations in which a human driver had to take over from the computer again) than GM and 6x more than Zoox (2018).

Value chain and investment opportunities

The autonomous driving technology value chain shows interesting investment opportunities for InnoEnergy. Within the hardware space (sensors and central control units), ETM could invest in companies that improve the capabilities of sensors (e.g., higher accuracy, less false alarms) or that develop cheaper sensors as well as alternatives with the same capabilities. In the area of central control units, the hearts and brains of autonomous driving, ETM could provide support for the development of new systems on a chip. In in-car software (perception, decision-making, middleware), there are opportunities for players that test algorithms and provide (virtual) training environments. There is also a need to certify algorithms and confirm/ensure their way of working. In the back-end software (HD map and location-based services) further investment fields could help automate the map creation and update processes, as well as the introduction of software standards across the industry. One more interesting field is the car data for which new monetization options could be created. Within engineering services (integration and validation, production) players could convert traditional vehicles into AVs – either in their own production facilities (e.g., for supporting scale-up) or by providing engineering services, using third-party plants. Companies could also offer "sensor leasing" to help offset the high capex costs.

Looking at possible use cases for autonomous vehicle technology, robotaxis will be the most important one, but the most uncertain when it comes to deployment – partly due to the regulations. "Climbing up" the ladder from level 2 entry features through level 3 and level 4 highway pilot, level 4/5 robotaxis could replace private car sales at some point.

The adoption of these new vehicles will start in suburban areas as they provide a relatively easy environment for autonomous driving – with few obstacles, wide lanes, and simple driving scenarios. First pilots are on the road already (e.g., Waymo in Phoenix/Arizona), and in 2021/22 we will see more of those. At a later stage, urban areas – with more pedestrian, double-parking, and other more complicated driving scenarios – will follow (between 2023 and 2027). Even more complex are superdense city centers like downtown Tokyo with frequent and complex obstacles and edge cases – adoption will likely not happen before 2025 to 29. And last, rural areas will be covered – due to the difficulty and expensive mapping needed, and unique challenges such as high differential speed. These regions will only be covered between 2027 and 2035.

However, this spread of robotaxis will need to be managed: some 20% of vehicles on the road in European cities could, in theory, be robotaxis by 2030. Hence cities will be at the forefront of a guided adoption of these vehicles which could in turn reduce the overall vehicle fleet. But the regulatory landscape will play a dominant role in the roll-out and acceptance of this technology. The USA and China will likely lead, and Europe will follow.

Besides passenger vehicles, trucks will be an important use case for autonomous driving technology. An automated truck can yield some 10 to 15% fuel savings over a conventional one – and most likely we will see autonomously navigating trucks on highways (level 4 autonomy) much earlier than we will see large fleets or robotaxis in urban centers. Already today we see autonomous trucks being operated in geofenced areas such as harbors, logistics centers, or in mining operations (e.g., Einride in Sweden).

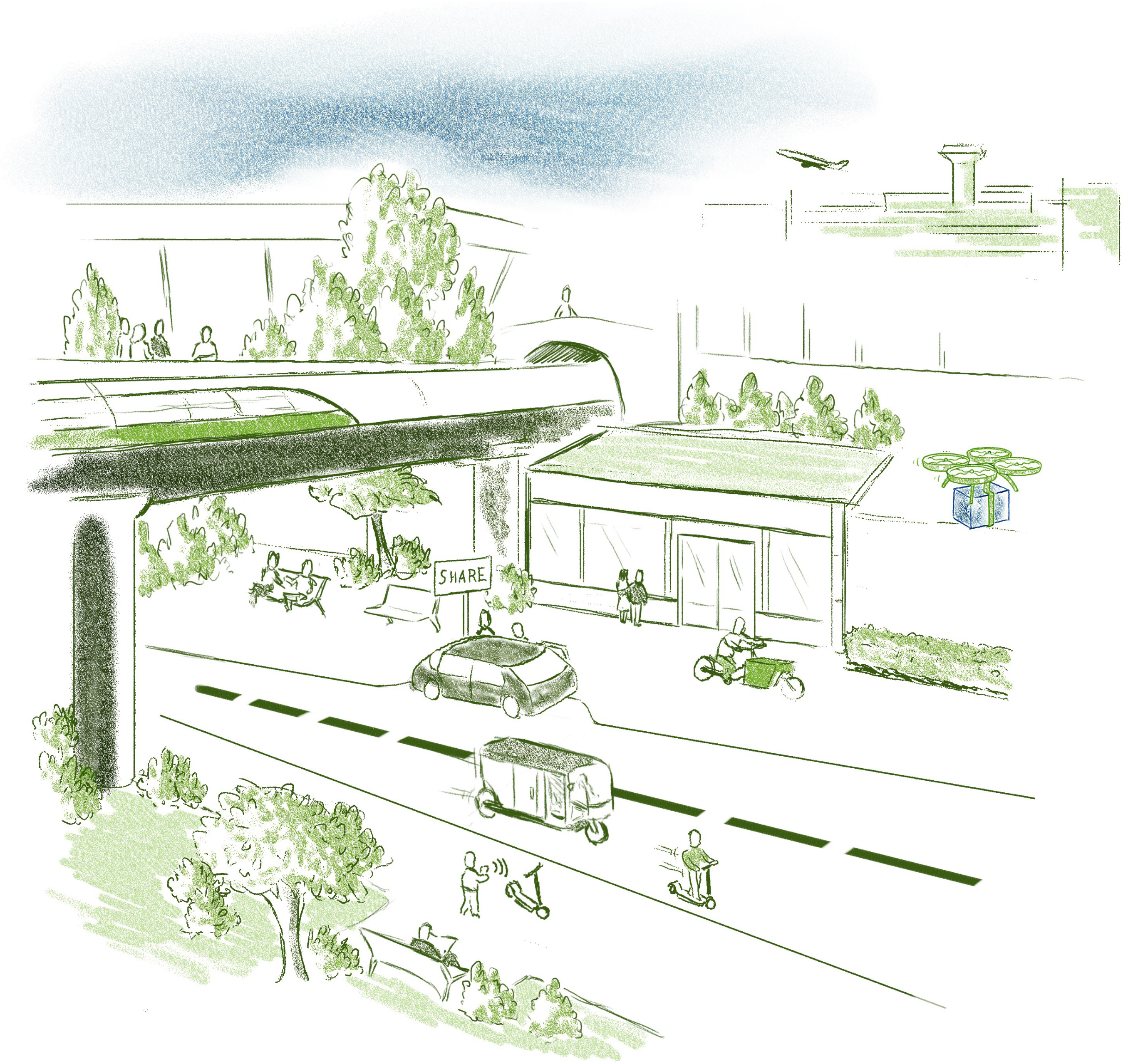
Robotaxis – and earlier on, vehicles with advanced driver assistance systems (ADAS) – strongly rely on sensors to map and understand the environment. Consequently we will see strong growth on sensors – from USD 30 billion in 2020 to USD 63 billion in 2030. Camera and radar are the largest sensor class in ADAS – later in the 2020s also LIDAR will experience a strong market growth – as LIDAR's capabilities are very valuable for AVs. Restrained by the high systems cost which limit widespread adoption we expect that the solid-state LIDAR will be the technology of choice in the future. Multiple startups compete very successfully in that field – also due to significant funding.

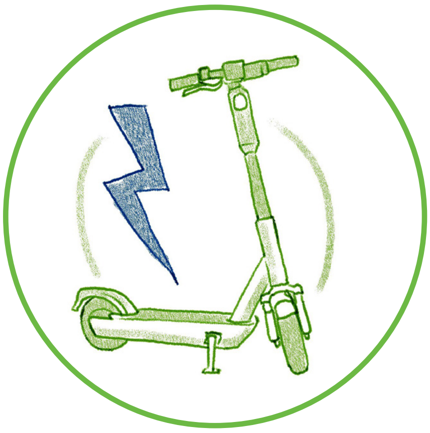
In 2030, the LIDAR market will be biggest for private cars (with USD 3.9 billion), followed by robotaxis (USD 3.2 billion), trucks (USD 0.7 billion) and other applications such as in agriculture or mining (USD 1.8 billion). Whereas the private car markets will be big due to the high volume, the robotaxi and truck markets will grow because of the need of those vehicles to incorporate multiple sensors.

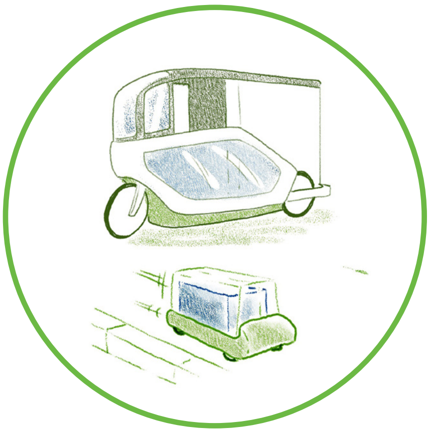
Going beyond the necessary hardware, also the software market for ADAS/head-up display software will increase – from USD 15 billion in 2020 to over USD 40 billion by 2030 (CAGR of 11%). Software will be a critical and highly profitable part of the AV value chain. We expect that tech players – due to their competence in this field – will join typical Tier-1 players as suppliers. However, the increasing complexity in software is a key challenge for the automotive industry; as the modern vehicle architecture has to be adjusted in order to manage complexity and quality. Another challenge are cyber-security and hacker attacks which could undermine the public's acceptance of autonomous vehicles.

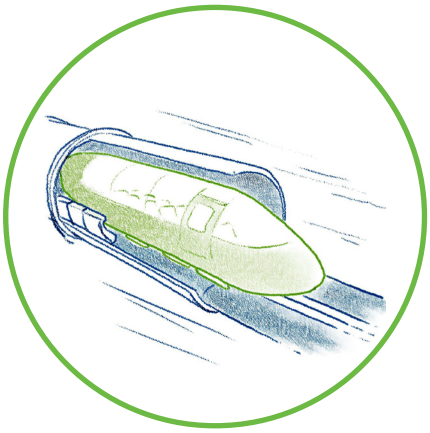
As discussed above, the market structure for autonomous vehicle technology will be different from today's classic automotive supply chain. Several players will work together to develop both the hardware and software in this field – from OEMs, carelectronics system suppliers, software, and tech giants to semiconductor companies as well as computing and connectivity players.

3 Innovative vehicle concepts









For decades, the car has been experienced as "freedom machine" – one could start the engine and drive hundreds of kilometers, wherever one wanted. Most cars were built on a "one-size-fits-all" approach and have been used for the daily commute, for shopping on weekends, and for the yearly holiday trip. In future, we will see more varieties of vehicles beyond cars tailored in specific use cases – from the small commuter vehicle such as e-bikes or e-scooters to long-distance cars, from autonomous delivery pods to large trucks.

Mobility services for people – impact across 3P principles

Planet

Energy demand

The energy demand per km traveled is significantly lower for e-bikes and e-mopeds than for passenger cars. The energy required to produce an e-bike's battery (22 - 30 kg CO2) already recovered after 100 km not driven in a car.

Emissions

CO2 emissions per passenger are about ~ 60 x less for an e-scooter than for a single passenger ICE, and ~ 8 x less than for a pooled EV. In Munich, CO2 emissions savings in 2030 could reach some ~ 80,000 tons through micromobility.

People

Accessibility

The fueling costs of e-scooters are ~ 63 x less than for a conventional ICE, and ~ 27 x less compared to an EV. Micromobility can connect users to public transport, providing more people with access to these services – as about 40% of US micromobility rides go from/to public transport.

Health

With its around 8 to 60 x lower CO2 emissions compared to cars, micromobility improves the air quality especially in urban areas. And: 49% of micromobility users would otherwise have chosen cars (including ride hailing). Moving to, e.g., e-bikes also has health benefits.

Profitability

Market demand

In 2030, the market is expected to include 27 million vehicles and be worth USD 400 to 500 billion. About 46% of all US vehicle trips are less than 5 km, ~ 60% are less than 8 km – different micromobility form factors could address these use cases.

Business model/GTM

Multiple go-to market options are available along the value chain, ranging from component manufacturing (currently worth ~ 15 to 25% of value), operating fleets (at ~ 30 to 45%) to, e.g., mobility services (capturing ~ 30 to 40% of value).

Technology

A range of form factors is already available, additional form factors for new use cases are likely to emerge (e.g., inclement weather, shopping). There is an additional opportunity to increase addressable share of passenger km traveled from currently, e.g., 50 billion km in Germany (10% of total).

Future structure/competition

Many new players have launched their services due to low initial investment and deployment costs. The number of scooters needed per city is limited, and the cost of hardware is fairly low, partly driven by production in, e.g., China. The market will consolidate as scale is essential to ensure high utilization.

Value chain and investment opportunities

The value chain for the last-mile mobility of people consists of the actual manufacturing (R&D, components, integration), the asset provision (financing, asset ownership), the fleet operations (charging, relocation, maintenance) and the mobility services chain (business owner, licensing, payments, mobility platform).

In manufacturing, there is an opportunity to develop new form factors to address additional use cases. Moreover, one pain point at the moment is the lifespan of the vehicle: one could think of better design, maintenance, etc. to reduce the fleet turnover, both which improves sustainability and profitability.

In operations, new players could develop third-party or even autonomous relocation systems for micromobility devices, improve the charging systems, use exchangeable batteries, and offer remote maintenance to reduce costs and extend lifetime.

In mobility services, companies could better integrate their micromobility offer with, e.g., public transport or offer innovations such as flat rates or mobility budgets across operators.

The last mile of people transport – micromobility – can address a large share of trips with ranges of up to 8 km. Possible means of transport are (electric) bikes, scooters, and mopeds. 10% of all trips in Germany could be addressable, the global market size is some USD 400 to 500 billion large. The vehicle fleet could be as big as 27 million vehicles by 2030. The field is interesting for many different players – ranging from auto OEM supplier, startups, banks, transport operators to mobility service providers.

Using today's technology, e-mopeds can account for around 60% of market and vehicle share due to longer trip distances; e-bikes and e-scooters each account for around 20%. In the future, new form factors (e-trikes, bikes with a roof, etc.) could be picked up in micromobility as well as for personal use. This could help increase the share of potentially addressable kilometers captured by micromobility.

Today around 50% of shared micromobility trips cannibalize non-car-based mobility. The other half substitutes the use of a private car (25%), ride hailing (9%), car sharing (8%), and taxi (7%).

Regulation is and will be central to bolster micromobility's role in future (urban mobility). Cities will be crucial to define the "rules of the game" in their centers – potentially making micromobility more attractive compared to private car use (e.g., by closing areas for cars, increase parking fees, financially supporting micromobility sharing schemes).

The last mile for goods – impact across 3P principles

Planet

Energy demand

When a large share of the 7.2 million delivery vehicles in the global top 100 cities by 2030 are EVs, this could reduce energy demand significantly for the last mile of goods (depending on energy efficiency of EV and battery production).

Emissions

Without intervention, CO_2 emissions are set to grow by 6 Mt to 25 Mt by 2030, up from 16Mt in 2019. However, it is possible to reduce emissions by 30% with limited disruption only by combining regulation and private-sector initiatives.

People

Accessibility

Without intervention, last-mile induced commuting times would increase by on average 21%. And: lower delivery costs are possible, enabling more consumers to use online deliveries.

Health

Replacing delivery trucks and vans with cargo e-bikes or EV last-mile solutions could reduce inner-city pollution, especially if deliveries are moved to night times. However, delivery robots and droids deployed at scale would significantly increase congestion.

Profitability

Market demand

Overall, last-mile services generated revenues of ~ EUR 70 billion worldwide in 2015. The global market for autonomous delivery vehicles has the potential to reach a size of EUR 2.5 billion by 2025. The number of delivery vehicles is expected to grow by 36% by 2030 to 7.2 million in the top 100 cities.

Technology

In the future, autonomous vehicles are expected to provide two-thirds of B2C deliveries in developed countries. Drones and droids will change niches of last-mile delivery until 2025 – and in the long run, AVs and robots will revolutionize it. We will also see (e-)bike couriers for instant deliveries.

Business model/GTM

The value chain options range from providing, e.g., autonomous goods vehicles (AGV) or courier bike components and systems to operating these services (on behalf of logistics players) or adjacent/supporting services (charging, maintenance, financing, remote operations).

Future structure/competition

Currently, we predominantly see smaller players driving the innovation in tech-driven niches; but larger logistics players such as Amazon and DHL start to invest in dedicated form factors.

Value chain and investment opportunities

In last-mile logistics there are different business areas which cover a wide range of use cases – from deferred delivery (arrives some day) and time-definite delivery (arrival next/specific day and time), through same-day delivery (arrival on same day) and instant delivery (delivered right away – less than ~ 2 hours), to B2B store delivery and B2B full truckload/less-than truckload delivery. In addition to the use cases, the "type" of package delivery can vary from relative light-weight courier or parcel to food and drink (e.g., barrels of liquid) requiring different performance specifications of the vehicle.

Across these business areas multiple services and innovative business models are thinkable. Players can focus on developing rerouting software and/or software to fully integrate different last-mile goods transportation options into existing systems. Companies could also support and deploy EVs, especially where they have not reached TCO parity yet. Other options are to improve space utilization (moving less "empty space"), developing new form factors, e.g., for cargo e-bikes or to combine people and goods transport to increase fleet utilization. Another angle could be to support the pooling of load, e.g., based on connectivity and advanced analytics. Players could also develop their business in operating e-cargo bike logistics services, parcel boxes/shops, or trunk and office delivery services.

The market for urban last-mile deliveries will grow by 78% through 2030. This is driven by customers (2.1 billion people will buy online by 2021 – e-commerce with 20% market share by 2023), products (e.g., 45% of furniture will be sold online by 2030) and delivery options (20 to 40% growth in same-day delivery, 10% growth yearly in instant delivery).

Today, delivery is not a self-standing business, but only one step in the value chain of larger retail, fulfillment, and logistics businesses. This will change going forward, driven by technology – also to reduce the negative impact that would come along with the growing last-mile business.

Mission-optimized vehicles – impact across 3P principles

Planet

Energy demand

A more efficient design architecture of mission-optimized vehicles helps reduce energy demand. For example, car-sharing vehicles focused on urban areas need less power than average vehicles and can therefore use smaller motors.

Emissions

Mission-optimized vehicles generally feature electric drivetrains and therefore reduce emissions compared to ICE-powered alternatives.

People

Accessibility

Mission-optimized vehicles generally reduce costs. This is due to their use-case-focused design and specifications. In turn, these savings could be translated into lower costs and thus into increased accessibility for customers.

Health

Electric drivetrains reduce emissions and therefore bear health benefits for citizens, especially as many mission-optimized vehicles address urban use cases (e.g., delivery bikes, electric vertical takeoff and landing [EVTOL]).

Profitability

Market demand

Car-sharing vehicles could account for up to 28% of vehicle sales in 2030 in medium- and high-disruption scenarios. With more than 4.5 million Uber and Lyft drivers globally, sharing-optimized vehicles would already have a significant market today.

Technology

There are many opportunities to address for mission-optimized vehicles, always including technological dimensions. One example are electric planes for which the key technological challenge to address is energy density (batteries having a ~ 50x lower energy density than kerosene).

Business model/GTM

Across mobility/transport modes, multiple business models regarding component and vehicle production are possible. Mission-optimized vehicles could target, for example, the USD 190 billion "base vehicle" market for autonomous vehicle operations.

Future structure/competition

Within markets, startups today often lead the development with support from incumbents – e.g., electric-plane systems are developed by startups together with Rolls-Royce or Airbus.

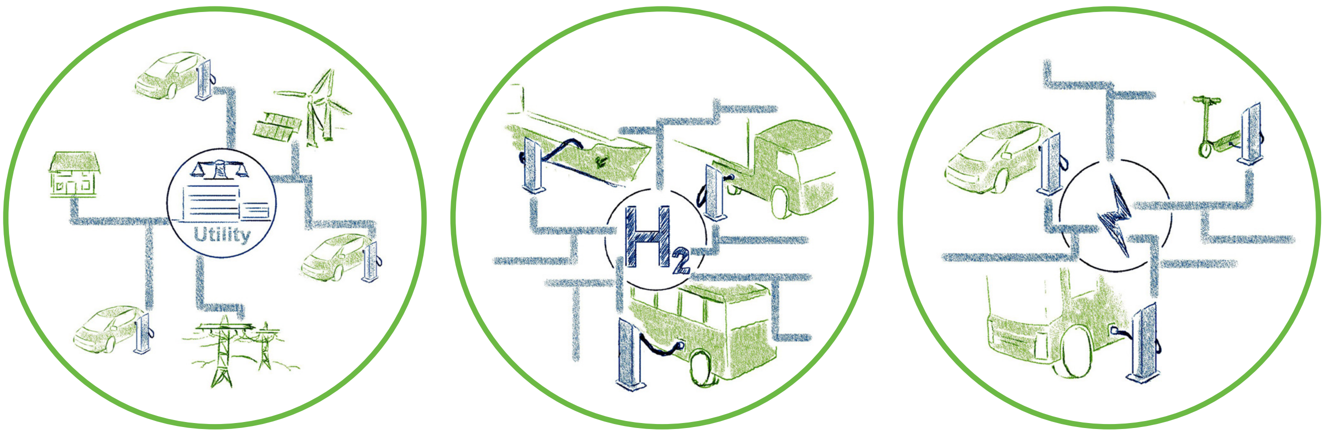
Value chain and investment opportunities

Mission-optimized vehicles could play a significant role in different mobility use-cases – with opportunities in many of those. For two-/three-wheelers and micro-mobility, there are opportunities for manufacturers of cargo e-bikes/tikes for urban deliveries, or by electric delivery fleets. For cars and shuttles, concepts for shared shuttle services (especially for lower speed) or for shared shuttle operations could be promising. For longer distances, sleeper buses which replace planes could be an alternative. In commercial vehicles, "street-scooter"-like delivery vehicles could be an investment opportunity; in rail, intelligent freight cars for autonomous repositioning – or even a hyperloop for people and goods are thinkable. In marine environments, electric cargo tugs and tenders for containers would be an alternative – and in the air, electric regional jets (for less than 50 passengers) or electrical vertical takeoff and landing (eVTOL) vehicles could be an alternative in urban areas. In construction/utility and off-road use, AV mining trucks and connected equipment are potential investment areas.

The market demand exists across all dimensions of vehicles described above – in the following we will concentrate on mission-optimized vehicles for car sharing.

Car sharing is a growth industry, accounting for up to 28% of new vehicles by 2030 – at the expense of private-use vehicle sales. Players have different options in this field: they could set up a dedicated shared-mobility platform, they could build a stand-alone purpose-built vehicle; or they could build a shared mobility variant of existing vehicles. All these options are already feasible today. The bottom line is that these vehicles could be operated at about 15% lower cost than conventional ones. At the same time, they could provide a superior experience for users and an improved value proposition to win new drivers.

4 Energy provision infrastructure



Putting EVs on the road is only one part of the solution to reduce GHG emission from road transport. In order to make transport sustainable, the energy provision infrastructure must “grow” with the uptake of EVs – based on renewable energy.

Electric charging infrastructure – impact across 3P principles

Planet

Energy demand

The energy demand will increase to 65,000 GWh in 2030 to support the required fleet of EVs to reach the EU emission targets for 2030. An improved charging infrastructure helps decrease the required standard battery size, thereby reducing the need for energy-intensive mining and battery production.

Emissions

With that, a better charging infrastructure also reduces indirect CO2 emissions through increased proliferation of BEVs, as it helps reduce range anxiety – one of the most important factors limiting customer acceptance of EVs today.

People

Accessibility

A better charging infrastructure increases accessibility and is hence critical for users who cannot charge vehicles at home – and therefore also constitutes a strong social component. In China, for example, public charging will deliver around 80% of total EV energy by 2030, up from 60 to 70% in 2020. Moreover, a large charging network is required to enable longer- distance travel, e.g., trips of more than 100 miles, which represent 3 to 6% of total trips.

Health

This leads to an indirect reduction of pollution by enabling more EVs on the road, thus replacing ICEs.

Profitability

Market demand

There is a significant revenue potential from charging solutions given the increasing demand. The total number of charging points required by 2030 could reach ~ 46 million globally, with ~ 15 million in Europe. The necessary capex sums up to ~ USD 17 billion. Public chargers (including, e.g., in retail locations) will play an important role, with home charging being most important in the US and Europe.

Technology

Faster charging technologies (DC) will help address range anxiety, but charging speeds are limited by a fleet's in-vehicle technology rather than charging point technology. AC will remain the most used charging type (~ 55 to 80% depending on region). New technologies such as wireless charging are likely to gain importance from 2020 onwards but remain less used compared to other methods.

Business model/GTM

There is a multitude of potential customers in B2B and B2C markets for both hardware and software solutions. The opportunities range from platform player and supporting services (e.g., asset installation or maintenance) to more asset-heavy investments in infrastructure. However, network density is a critical profitability driver across most business models.

Future structure/competition

Charging station suppliers are made up of a mix of established hardware providers and startups, with some players cooperating with OEMs to gain market access. Charging service providers often come from the utility or the oil and gas sector, with startups again entering the space.

Value chain and investment opportunities

There are numerous investment opportunities along the electric charging infrastructure supply chain – from charging point suppliers (technical development, production, sale) through charging point operators (installation and maintenance, operations, data management, billing) to charging point providers (roaming clearing center, energy and location services, information services).

ETM could support the development of two-way charging hardware to increase the share of vehicle-to-grid (V2G) operations. There is also room for improvement of the overall charging network structure by increasing the density of the strength of the grid. Finally, design improvement could be implemented to boost attractiveness and usability of charging points in both private and commercial use.

In charging point operations and service provisions, players could offer mobile top-ups (such as NIO does in China), and ETM could also support B2B companies that provide installation, monitoring, and maintenance services of chargers to increase uptime and availability. There is also potential in engaging in energy trading by using V2G technologies or energy storage systems. One of the main pain points for EV users today could be addressed by creating a platform solution to integrate multiple charging providers and payment options "under one roof." In this respect, an accurate mapping of available charging points including their status and the opportunity to book charging slots would be highly welcomed by EV owners.

There is a consistent connection between charging infrastructure and EV market share. Markets with higher EV share such as Norway, Sweden, the Netherland or China all have a superior charging infrastructure. Based on the EU goal to reduce CO2 emissions from transport by 37.5% by 2030 (compared to 2020), around three million charging stations will be required to support the buildup of the EV fleet. However, the optimal setup will depend on consumers' charging patterns and technological progress (e.g., charging speed). Players hence need to take an ecosystem view given the many moving targets, such as EV adoption rate, consumer charging profile, and charging location preference. A successful network will cover all relevant use cases, from home charging to work or destination charging as well as on-the-go charging. Each of those charging solutions requires a dedicated setup (e.g., charging speed, billing). There will be significantly different charging behaviors across regions: whereas 44 to 64% of charging will happen at home in the US, this number goes down to 28 to 40% in Europe, and even to 9 to 13% in China. Consequently, Europe needs some 15 million chargers by 2030, with around USD 17 billion capex investment (without generation and grid upgrades).

Hydrogen infrastructure – impact across 3P principles

Planet

Energy demand

Hydrogen is especially attractive for long-distance and freight transport, which account for a high share of energy demand compared to, e.g., short urban trips. Moving these segments to hydrogen reduces energy demand, as fuel cells are up to 60% more efficient vs. ~ 35 to 40% for most ICEs.

Emissions

CO_2 emissions are reduced indirectly, not only for passenger vehicles but across different mobility modes, including shipping, which currently emits ~ 940 million tons CO_2 annually (~ 2.5% of total) and accounts for 13% of the EU's transport-related emissions.

People

Accessibility

A better refueling network would increase customer choice, making hydrogen a more viable alternative to BEVs. This enables more people to own and use local emission-free vehicles. However, creating this larger network is a significant challenge due to the currently low number of users (and hence a difficult business case).

Health

Health will be improved due to lower emissions and particles of hydrogen vehicles compared to ICEs.

Profitability

Market demand

By 2050, the potential market share will climb to 20 to 40% for trucks, buses, and passenger ships. A bigger vehicle fleet will lead to infrastructure demand. Especially commercial vehicles increase infrastructure demand due to 10 to 20x larger tanks and a higher utilization factor compared to cars. More than 3,000 refueling stations are expected by 2025 (according to Hydrogen Council), up from ~ 400 today (International Energy Agency).

Technology

The projected cost for a hydrogen fuel station is at USD 1 to 2 million (size-dependent). This will likely decrease due to economies of scale. Alternative means of storage for hydrogen are currently being explored, with liquid storage potentially suitable for larger hydrogen volumes due to smaller tanks. This could reduce infrastructure cost (e.g., storage, transport).

Business model/GTM

The technology is generally available, but a significant scale-up will be required to reduce costs. Opportunities exist along the value chain, including developing recharging hardware, providing support services, and in operating stations. In general, it will be important to develop an ecosystem of infrastructure and vehicles in lockstep.

Future structure/competition

Currently, there is limited competition and consolidation in the hydrogen infrastructure industry, with, e.g., road transport recharging stations usually being situated in individually operated locations. This offers an opportunity for large players to create a strong position.

Value chain and investment opportunities

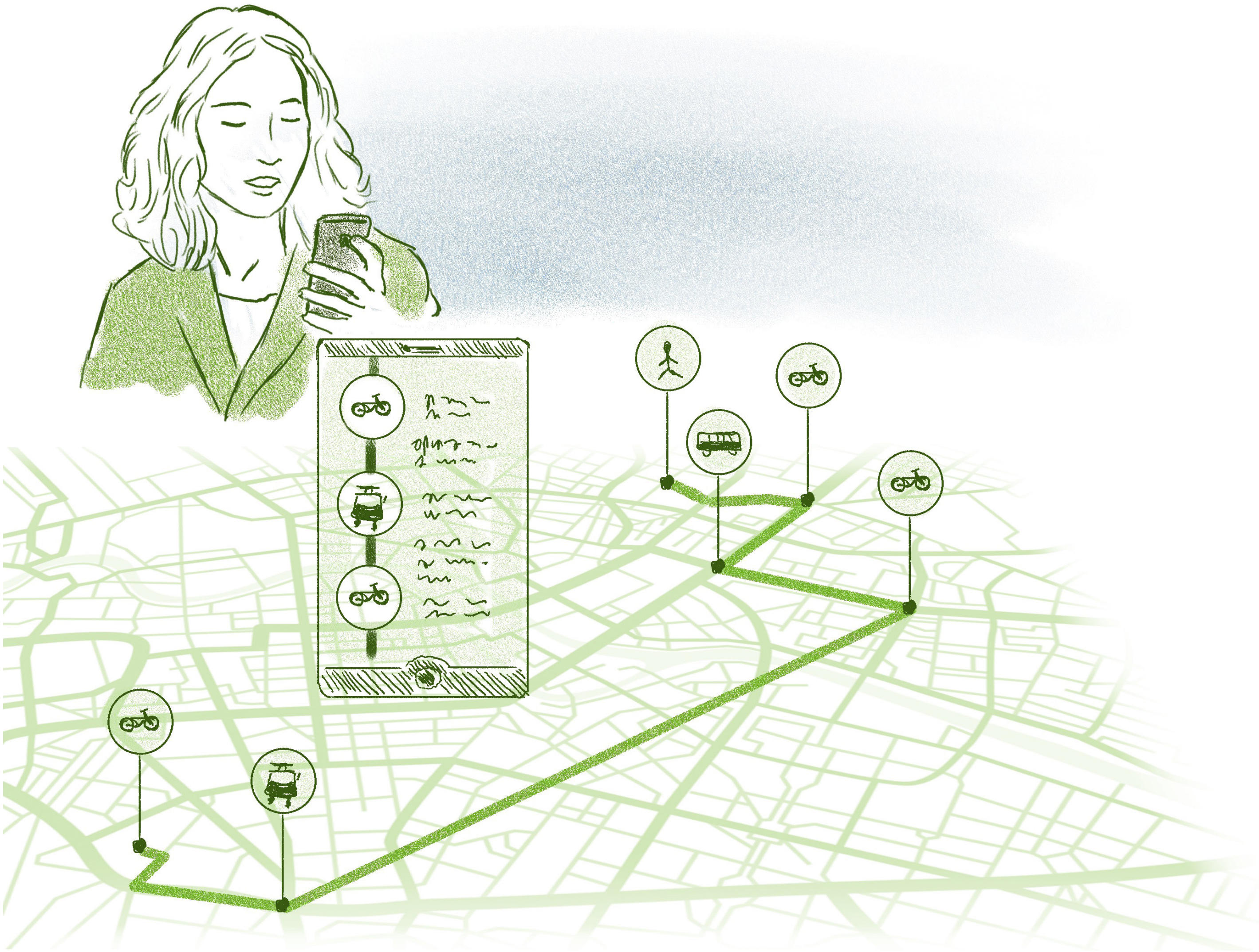
The hydrogen infrastructure value chain consists of both hydrogen recharging solution suppliers (technical development, production, sale) and hydrogen recharging station operators (installation and maintenance, operations and supporting services, data management and billing).

In the development and production, companies could for example develop mobile refueling options or cheaper recharging hardware; and produce those. Later in the chain, businesses could concentrate on supporting services, such as installation, monitoring, and maintenance of the infrastructure to increase availability. Moreover, there are multiple opportunities in the operations of such hydrogen refueling stations (HRS): operating decentralized hydrogen generation (e.g., electrolyzes), operating a recharging network, operate transport infrastructure to supply recharging stations with hydrogen, providing clean energy for hydrogen generation, or providing accurate mapping of available HRS and their status to customers. Going one step further, players could also create a (virtual) network by integrating multiple refueling stations.

The big advantage of hydrogen over DC fast charging is its charging speed: it is 15 x faster, today. Logically, the space required for HRS is much lower – and overall it is 50% less capital intensive than a fast charger.

Many countries have announced plans to build HRS by 2030 – adding up to more than 5,000 by then (today there are less than 1,000). Hydrogen mobility Germany announced 400 HRS by 2023, Scandinavia up to 150 by 2020, and the UK up to 1,150 by 2030. China want to build more than 1,000 HRS (for more than 1 million FCEVs by 2030), Japan 900 HRS by 2030, and South Korea 300 HRs by 2022.

5 Mode-shifting new mobility services



You just need to be in the city center of a random metropolitan area during the rush hour – and you will quickly agree that our current model split is not sustainable. The heavy use of private cars as predominant means of transport in cities will be restricted – through regulations issued by city authorities, but also by new mobility services. They will make the switch to another means of transport not painful for the individual, but can instead even be rewarding in terms of better user experience, comfort, price, and speed.

Mode-shifting new mobility services – impact across 3P principles

Planet

Energy demand

There is an opportunity to encourage shared mobility and public transport, with significantly lower environmental impact compared to private passenger car use.

Emissions

New mobility services have a positive impact on emissions when they replace a private car. An example from the Nordics shows that switching from private ownership to MaaS could result in 1.3 to 7.2% CO2 reduction in the region.

People

Accessibility

For users driving less than 20,000 km per year, sharing autonomous vehicles is more cost effective than owning. This applies to 89% of the urban population.

Health

Reducing the private use of passenger cars lowers emissions and therefore improves citizens' health. Multimodal mobility can promote or even incentivize, e.g., e-bikes or walking instead of vehicle use (Celis-Morales et al., 2017).

Profitability

Market demand

The European MaaS commission market will be worth EUR 180 to 380 million by 2023, with data sales and advertising worth an additional EUR 60 million. Up to 2.7 million shared vehicles could be on the streets in 2030, plus 25 to 30 million micromobility vehicles. This constitutes a large vehicle fleet available for MaaS.

Technology

The user interface is not especially complex. The focus is on APIs and the integration with vehicle and service providers. Opportunities exist for, e.g., predictive analytics to incentivize specific routes or times. This also requires deeper integration with cities' transport systems – and hence a good understanding of cities' priorities.

Business model/GTM

Different monetization models are available: payment per booking (commission), advertisement, fixed operation cost, and data sales (as adjacent business). Currently, there are very few multimodal subscription services that could fully replace car ownership.

Future structure/competition

With shared AVs available, mobility solutions will be more cost effective than ownership if users drive less than 20,000 km a year, which applies to 89% of urban users. New players such as Uber and Lyft enter the space and aim to become "one-stop shops" (from micromobility to aerial mobility).

Value chain and investment opportunities

New mobility services comprise different value chain steps – from hardware to service providers and aggregator platforms.

The hardware aspect has been covered in this report (in the section "innovative transport concepts"). In the service provider and aggregator field, multiple investment opportunities are available for ETM. Companies could provide connections to, e.g., public transport operators, which are currently most complex to integrate into multimodal service offers. Players could also help make public transport more efficient (e.g., by optimizing bus routes, peak pricing, scheduling) based on user data and demand prediction across all modes of transport to match capacity and demand (e.g., for micromobility or shared vehicles). Dynamic pricing could be another powerful lever to manage utilization and to maximize revenues (using off-peak tickets or cheaper rides) – as offered by GreenFlux. A multimodal citywide mobility backbone would enable cities to manage public transport, and mobility service providers to work together – and integrate their service offers at the front end and the back end (similar to WunderMobility). This could also serve as a basis for a mobility budget across platforms (like Everride) or monthly subscriptions (fixed fees to discount rates for selected routes).

Consumers' mobility preferences change dramatically – and become less car-centric. Some snapshots:

- 75% of Chinese believe autonomous vehicles will be safe (up from 38% in 2017).
- 36% of US citizens use ridesharing (up from 15% in 2015).
- Only 29% of men aged 17 to 20 in the UK have a driver's license (compared to 51% in the mid-1990s).
- Cycling is on the rise – 5% of journeys in London are made on bikes.

New business models are emerging to address these needs – customers have more freedom of choice as ever before:

- 9,000 e-scooters are on the streets in Berlin.
- E-bikes stand for 50% of revenues from bike sales in Germany.
- The number of micromobility trips rose from 35 to 84 million from 2017 to 2018.
- USD 12 billion have been invested into the global e-hailing market since 2015.
- MOIA has 50,000 registered users in Hanover (10% of population) four months after its launch.

Overall, we already see a shift towards greater multimodal and shared transport services: from individual car ownership as the dominant form of transport to the private car being one form of multimodal, on-demand, and shared transport. From limited consumer choice and few service levels to more choice and many service levels. From government-funded public transit to public and private transit operating in parallel. And from an unconnected, suboptimal, analog transport system to an on-demand, connected system that uses data to unlock efficiencies.

When analyzing the market for shared mobility in more detail, it is clear that car rentals still dominate in terms of market size (EUR 14.3 billion revenue in Europe in 2020). However, new shared mobility models such as ridehailing are growing rapidly. With EUR 7 billion revenue in 2020, ridehailing will be the biggest new mobility service; followed by multimodal travel management (EUR 4.6 billion), carsharing (EUR 1.5 billion) and P2P carsharing (EUR 0.4 billion).

Overall, shared mobility covers a wide range of modes – from car rental, public transport, taxi/licensed driver services, e-hailing, dynamic shuttle services, and pooled e-hailing to car sharing, P2P car sharing, micromobility, and urban aerial mobility. Shared transport modes like ride hailing, micromobility and car sharing can become part of consumers' modal mix. However, a large share of respondents has never used these modes – 61% for car sharing, 57% for micromobility and 53% for ridehailing. Private vehicles are still the most frequently used transport mode globally, with public transport being the second-most used option worldwide.

Today, and despite the market's size, the business for many new mobility providers is not yet cash positive – mainly due to high marketing and sales costs as all players engage in price wars to gain market share and build a customer base. However, Uber was able to reduce costs as share of revenues over recent years – this might lead to a positive business case in the future.

At the same time, we see the rise of MaaS and integrated mobility platforms that offer flexible mobility choices. These combine a wide range of services in a single user interface – from which customers can choose the mode most convenient for them. Those multimodal platforms hence need to handle complex user journeys: from demand creation, planning, and booking to the journey, post-journey feedback, loyalty programs, and billing. And they need to integrate a wide range of mobility services, complemented by related activities such as payments. The European MaaS market is estimated to hit EUR 180 to 440 million in 2023.

Today, there is a wide range of players active in the market. Competitors include startups like Quixxit, Moovel, Moovit, or Rome2Rio, which often start with a national focus and then expand, and global tech companies like Google, which are increasingly entering the space.

Most platforms focus on bus, rail and train; rental cars, ride-sharing, and flights are less common. All analyzed players provide at least three mobility alternatives: on average, players cover 6.75 modality options. However, many multimodal platforms struggle today as the public transport market is too fragmented – which makes the service less attractive for customers and turns rollout and scaling into a challenge. Once these hurdles are overcome, the offer will be attractive to customers – and hence constitute an excellent investment opportunity for ETM.

Conclusion

To help solve the climate crisis, our mobility system needs to be decarbonized – quickly. InnoEnergy's purpose is to bring the strong European energy, transport and mobility landscape to a new level in sustainable energy usage and GHG. By identifying investment opportunities that help meet this purpose, ETM will hence concentrate on the focus areas zero-emission drivetrain, autonomous-driving technology, innovative transport concepts, energy provision infrastructure, and mode-shifting of new mobility services.

Thank you

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