AZT Automotive GmbH
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Analysis of Collision Damage to High-Voltage Vehicles

Anomalies and their Influence on the Damage Situation and Impacts on Insurance Rating

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Content

1. Preface – Brief View on Insurance Group Rating

In order to calculate the so-called type statistics in motor insurance, the German Insurance Association (GDV e.V.) receives data on the claims history of each insured vehicle from its insurance companies once a year and uses this data to determine the claims requirement per vehicle type, described by the manufacturer and type code number. The underwriting risk is derived from this loss expenditures and made available to the insurance market and the public in the form of a type class. The claims expenditures is formed as the product of claims frequency and claims average. The corresponding calculations are made for all three insurance classes, third party liability, partial coverage and fully comprehensive. As an important tariff feature, these type classes have a considerable influence on motorists' insurance premiums.

The vehicle manufacturer has a considerable influence on the claims experience and the resulting costs of the comprehensive insurance of his product. This is because it is possible to significantly optimise one's own product in terms of energy absorption, ease of repair, repair processes and spare parts costs and thus reduce the average damage. The OEM can additionally reduce the frequency of damage through damage-prevention measures such as assistance systems. Furthermore, in the case of unavoidable accidents, such assistance systems can have a loss mitigating effect by reducing the kinetic energy. In this way, the manufacturer has it in his hands to improve the total cost of ownership and thus the competitiveness of his product.

Through the annual review of the type class lists, in which the type classes are reevaluated and, if necessary, adjusted on the basis of the actual claims experience, the German market transparently rewards such investments by the manufacturer in its products with an adjusted type class, respectively through lower insurance costs for the customer.

While the design of a repair-friendly body or the integration of driver assistance systems is not a new topic, a completely new field of specific damage patterns has emerged in recent years with electric mobility. This concerns the high-voltage components which, due to high electrical voltages in accidents and during repair, comprehend new types of personal injury risks and are also among the expensive components in the vehicle. In the meantime, most vehicle structures have been adapted to the constructive protection of these systems. However, as damage experience shows, this is only the first part of the designers' task.

The high-voltage battery, with a considerable mass of several hundred kilograms and at least 30 % of the value of the vehicle, is particularly worth of protection. This protection is not always successful and in the event of damage, sometimes considerable problems are identified that can have a cost-increasing effect on an entire model series. The tasks of optimising the design, diagnosis, repair and handling processes for HV batteries currently still offer considerable potential for improvement.

AZT Automotive GmbH, Allianz Center for Technology, has investigated this in a study and presents some relevant aspects of damage in e-mobility in this document.

Due to the still small – but increasing - population with electric drives the facts presented are based in part on very small numbers of cases. However, the findings are generally supported by the experience of RCAR institutes that have access to data from larger vehicle populations, especially in China and the USA.

This document is intended to provide vehicle manufacturers with helpful information for improving their products by highlighting the need for optimisation in high-voltage vehicles. Not only the constructive protection, but also the active avoidance of damage by driver assistance systems promises special potential due to the currently above-average damage costs for high-voltage vehicles.

2. AZT Study on Damage Occurrence in High-Voltage Vehicles

An AZT analysis of market data (source: German Insurers Association GDV) found a markedly different distribution of damage types over several years, sorted by drive type: relatively constant over time, the damage types theft and fire, flooding, etc. are clearly underrepresented compared to conventional vehicles. In contrast, collision costs dominate the claims expenditure for battery-electric passenger cars (BEV) with a share of about 84 % compared to about 73 % for conventional vehicles. However, these data are highly aggregated and do not allow any detailed statements. Nevertheless, the market data show that the greatest levers for improving claims costs lie in collisions.

Already in 2017, a study by the AZT based on concrete Allianz claims data showed that the claims averages for collision damage in comprehensive insurance for BEVs are above the average of the conventional comparison group. However, it became apparent at the time that the exposure of BEVs differed in part from that of conventional vehicles, particularly with regard to mileage. Thus, a lower claims frequency (CF) could partly compensate for the higher claims average (CA).

Expensive individual claims and a cost situation that also deviated from the market average in subsequent years prompted the AZT to conduct a new study in 2022. In this study, the main factors influencing BEVs were examined. A corresponding study for plug-in hybrids (PHEV) is currently still in progress.

A random sample of 400 fully comprehensive collision claims with BEVs was examined in detail from Allianz claims for the year 2021. For comparison, 350 similar cases from a sample up to 2018 with purely conventional drives were available. Like the cases examined in 2017, these 350 cases were adjusted for inflation on the basis of the claims cost development determined by the GDV. They are also referred to as the reference in the following.

Accident characteristics

A first finding is that the occurrence of damage according to driver parameters, times of day and accident situations does not deviate significantly from that of conventional vehicles with drives exclusively with internal combustion engines (ICE). This is also reflected in the distribution of damage levels, which approaches that of conventional vehicles with increasing population size. However, a difference at the expense of BEVs in the claims range of €7,000 and above remains noticeable.

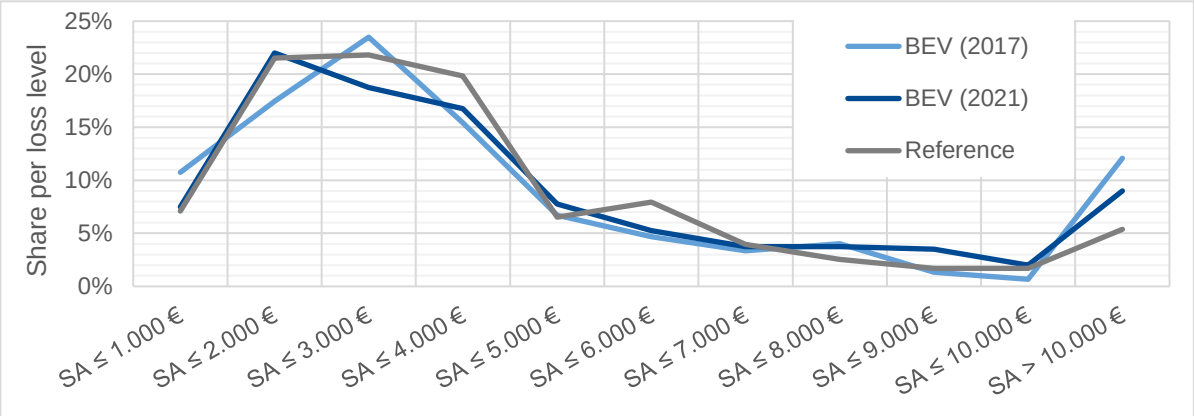


Figure 1: Distribution of collision damage according to damage levels, clustered

The damage average for BEVs is about 18 % higher than for the reference group. The median is still 6 % higher, which clearly demonstrates the effects of expensive damage that can be seen from the curves.

One recognised difference, however, is the location of accidents. While on motorways there are now roughly equal distributions, significantly higher proportions of BEV collisions occur in towns and significantly fewer outside towns, compared to ICEs. About half of the damage to BEVs occurs in car parks, garages and multi-storey car parks. Damage during parking and manoeuvring appears to be even more pronounced here than with conventional vehicles.

The speed distribution of the accidents is relatively comparable in both samples, with approx. 70 % in the range between reversing and up to 20 km/h driving forward. Significantly more damage than in the case of ICEs occurs in BEV vehicles when stationary, e.g. deliberate damage or hit-and-run accidents. The reason for this may be that the sample of BEV vehicles is significantly younger, so that this type of damage is reported to the insurer more frequently.

Largely unknown from the conventional world, some damage has also been found in BEVs due to incorrect choice of driving direction from a standstill with subsequent collision. Due to the high initial torques of the e-machines, these damages can also be expensive.

Demographic vehicle population information

The detailed analysis of the MOD collisions at the level of the claims data also allows the consideration of the persons injured in the insured vehicles. Since, despite the accident occurrence at comparably high speeds, such personal injuries were also found to be reduced, one may initially conclude that the BEVs have a higher protection potential. Here it is now important to consider the

population age. While the average age of ICEs in the conventional comparison group is approx. 4.8 years, the average age of BEVs is only 1.4 years. At the same time, however, the year of construction distribution is very different, as the ICE reference group was completed on the cut-off date of 31. December 2018. Therefore, the technical age of the two groups can be significantly different.

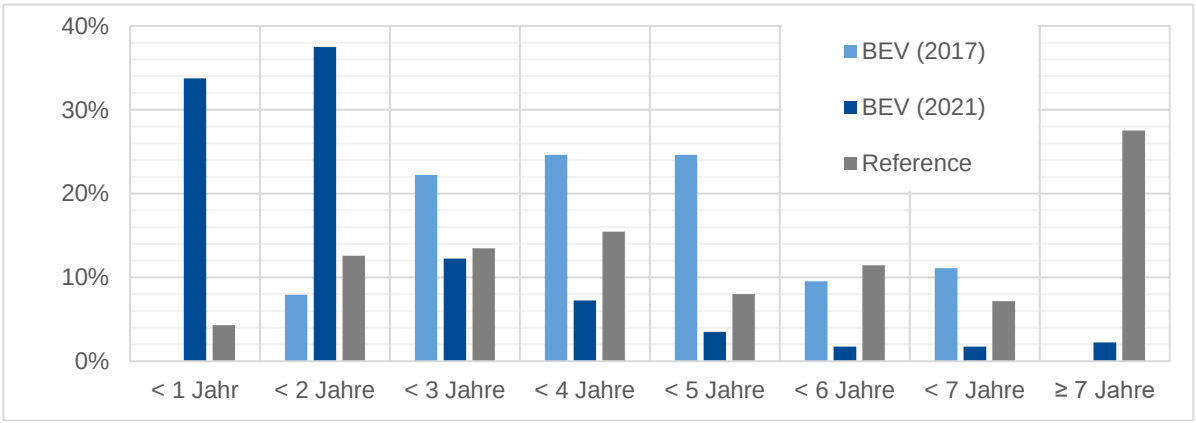
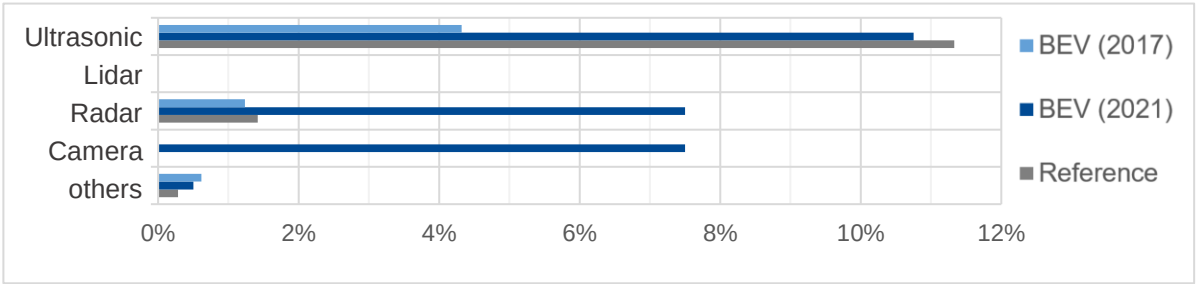


Figure 2: Distribution of first registrations

Influence of driver assistance systems

In the damages investigated for BEVs, in addition to a comparably high proportion of damaged ultrasonic sensors, a considerably higher proportion of damaged radar sensors was found. This is probably due to the lower average age of BEV vehicles as described above. Damaged cameras as in BEVs did not occur in the ICE reference group.



Graph 3: Sensor technology for ADAS found in the damages

The distribution of damage severity is also such that BEVs have significantly more light damage and significantly less severe damage than the reference.

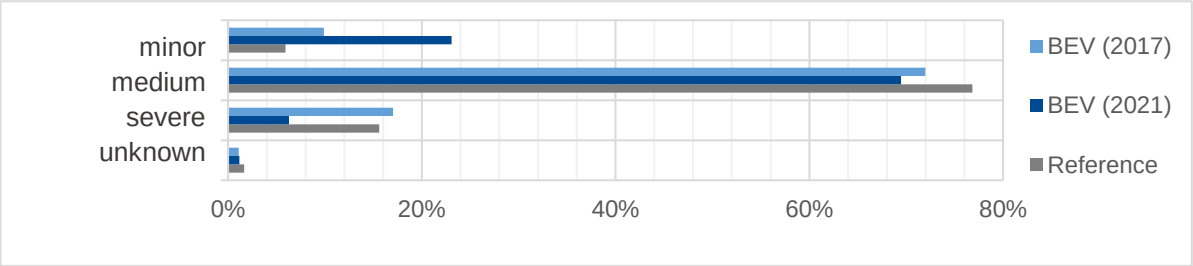


Figure 4: Loss severity for BEVs and reference group

The parts damaged according to the expert report or invoice also reveal a decrease in serious accidents in longitudinal traffic. Significantly fewer damaged front covers, headlights, side members and especially cross members are found than in the reference group. The bumper fascia, on the other hand, appears comparably frequently as in the ICEs. While headlamps and front covers can also be protected by design and construction, the reduced proportion of cross members compared to bumper fascia is distinct. This provides a strong indication that the ADAS, which are more common in the newer BEVs, have an avoiding or at least mitigating effect in longitudinal traffic.

At the same time, parking and manoeuvring are apparently not addressed to a greater extent by ADAS. Outside of vehicle-vehicle collisions, this is also reflected in the collision objects. Bollards, posts, poles" account for about 30 % and "walls" for another 24 %. The rear right side wall, for example, is also affected slightly more often in the BEVs. The distribution of collision objects generally correlates well with that of the reference group and therefore does not indicate any influence of an ADAS.

Specifics of the vehicle segments

The BEV vehicle segments found in the sample do not represent those of conventional vehicles. Not all segments are represented in the BEVs; a mid-size class has only existed since Tesla's Model 3. While in the 2017 study almost 70 % of BEVs were small cars and there were no SUVs, there are now just under 50 % small cars, and SUVs have been added, representing around 20 % of the portfolio studied.

The damage average CA of the small cars is about 13 % below the average of all BEVs, but 4 % above the reference value. The disproportionately large share of small cars thus dampens the CA for BEVs, which at +18 % (see above) is significantly higher than that of ICEs.

3. Cost Drivers

The question now arises as to where the generically higher claims costs come from. There are systemic and manufacturer-specific characteristics here. Previously unknown variables are in particular the frequency and extent of damage to the high-voltage system

An overview showed that, in comparison, both labour costs and parts costs were higher for BEVs than for ICEs, but not the painting costs.

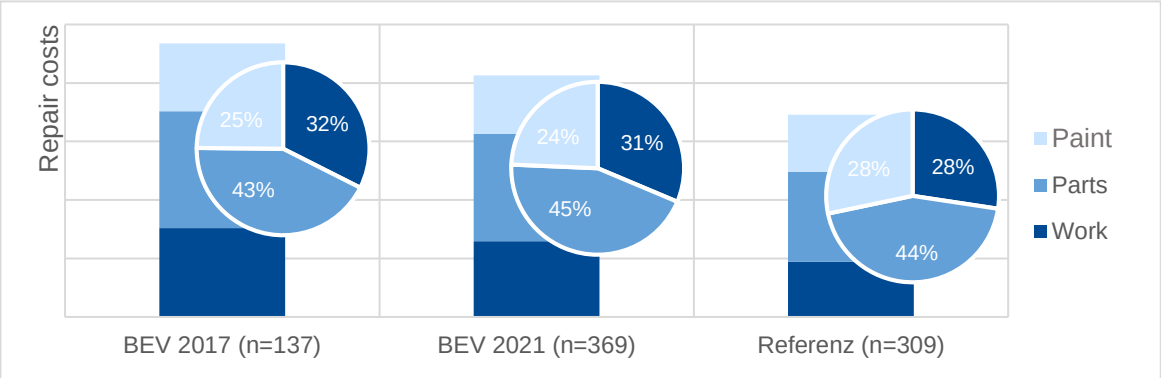


Chart 2: Proportionate repair costs after collisions (without total losses)

Systemic effects

High-voltage vehicles require certain handling steps in accident repair, such as disconnecting the high-voltage (HV) system, namely the deactivation. However, they also require certain qualifications, so that not every workshop may carry out all repair work. The influences of workshop costs have therefore been investigated. It turned out that in the case of BEVs, 23 % of the damage was repaired in independent workshops, while this proportion was 55 % in the reference group. The data found show that branded workshops charged 10 % higher hourly rates for BEVs than for the reference, while independent workshops charged roughly the same prices. In addition, branded garages charged about 6 % more time for BEVs compared to the reference, while independent garages charged 11 % less. Finally, the hourly rate in the brand workshop for BEVs is on average 48 % higher than in the independent workshop.

It is interesting to note that the difference in costs between the brand workshop and the independent workshop is more pronounced for BEVs than for ICEs. Overall, if a BEV is repaired in a brand workshop, the costs claimed are higher on average because both the hourly rates and the time rates are higher. However, since BEVs repaired in independent garages have smaller time rates

overall, it must be concluded that mainly smaller damages are repaired in independent garages. In fact the average bill is significantly lower with costs for spare parts one third less. The independent workshops are presumably not yet at the same level of qualification as for conventional vehicles. Nevertheless, the pricing of the brand-name workshops is clearly disadvantageous for the costs compared to the independent workshops.

There are manufacturers who do not have a workshop network, but work with partner companies. There are also manufacturers who prescribe tests of the high-voltage batteries in defined test centres. The costs are significantly increased in the latter cases, as both time expenditure and cost rates were found to be significantly increased once again.

Taking the reduced shares of independent workshops and their leverage on costs together, it becomes clear that workshop type is a significant factor for the CA of BEVs. It remains to be seen whether, with an ageing population and maturing qualifications of the independent workshops, the ratios here will converge with the reference group.

Systemic effects also include the deactivation of the HV system when accident repairs are required. The picture found is very heterogeneous both in terms of necessity and in terms of time expenditure and associated costs. Overall, the effect of disconnection is not significantly cost-increasing. But: In the case of individual manufacturers, this is explicitly different.

The manufacturer-specific effects include parts prices. Here, sample calculations for (RCAR) front damage of directly comparable models of the same brand showed that there are no observably higher parts prices for BEVs within the framework considered. However, in individual cases, a charging ports in the direct front impact area had a negative effect. In the Allianz claims examined, these actually ranged from € 500 to € 2,700 in repair costs .

Damage to the HV System

In addition to the charging ports, which were found in 1 % of the damages, there was damage to the control units or electronics and wiring of the HV system in 2 % of the sample. Nota bene, only collision damage is examined here. Partial comprehensive events such as marten bites were not the subject of the study, but have already been found to be very expensive in previous studies of damaged harnesses specific to the brand.

In also 2 % of the sample, the HV battery was damaged. It should be emphasised that there was intrusion damage only once, but five cases of underbody damage were found that required a complete replacement of the battery. The reimbursed costs for the HV battery only ranged here from € 13,300 to € 43,300. In two cases, the battery could be saved by replacing the casing. However, this replacement is very labour-intensive and costs between € 1,100 and € 2,200. In the cheapest case, at € 1,100, the replacement could be reduced to the underbody protection of the battery.

Figure 1: Example of replaceable battery protection, as installed e.g. at VW and Audi

Especially in the case of underbody damage, a more detailed explanation is necessary: In a technical sense, many manufacturers offer criteria that enable the expert to assess underbody damage in terms of function or functional safety. In insurance claims, however, the injured party is entitled to restoration of the original condition. This means that even technically insignificant and cosmetic defects in the visible area must be repaired. Since repairs to battery housings are not permitted or established, this leads precisely to the costly replacement of large components and a corresponding loss of resources. Particularly in cases where the battery has to be replaced completely, the customer may face the problem that a "new for old" deduction can lead to a high owner's contribution for the repair. However, if the insurer waives this deduction for the protection of the customer, this directly increases the claims costs relevant to the type class.

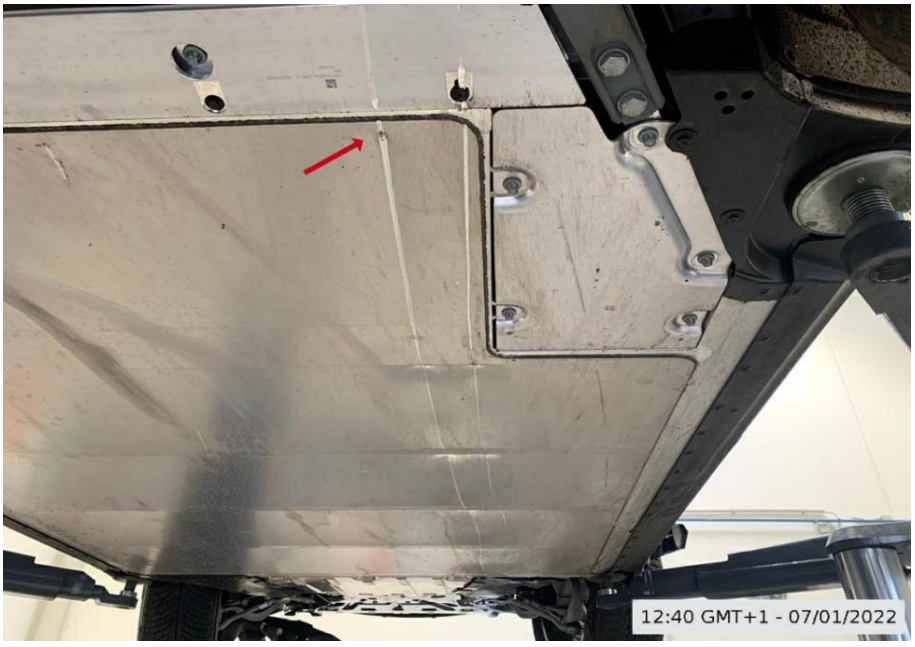


Figure 2: Example of damage to unprotected battery underside, e.g. found on BMW, Hyundai, Kia, Renault models.

Figure 3: Example of paint damage to be repaired on HV battery

Against this background, damage to the HV battery accounted for 2 % of all collision damage, but caused a good 7 % of the total damage expenditure. In order to verify this finding, the entire damage base of the year 2021 (MOD collisions) was checked for battery damage, confirming the data found.

In order to illustrate the effects of very expensive battery damage on the type class in comprehensive insurance, the analogy to total theft can be used as a first approximation. For vehicles with a total theft risk significantly above the market average, the type class is often increased by more than 2 classes due to this type of damage alone. With a frequency of 2 % and the identified costs for battery replacement, the conditions for a comparable relevance are met.

The factors of construction, diagnosis and handling processes for HV batteries are therefore of great importance for the insurance costs of the models. In addition, from the AZT's point of view, HV batteries must be comprehensively repairable, especially with regard to the reparability or replaceability and dismantling of the housing, individual battery modules or other important components.

International situation

The AZT has already determined an analogy between BEVs and petrol cars and PHEVs and diesel vehicles on the basis of the type classes in 2021 and has shown that the damage averages were higher than those of the conventional counterparts in each case. In the British market, BEVs have long been subject to a malus in the insurance rating of the ABI (Association of British Insurers), which is around 10 %.

Increased and expensive battery damage due to impact on the underside, primarily ground contact, has already been reported from the Chinese market in 2019.

In an AZT survey 2022, other RCAR institutions reported that they perceive battery damage from the underside as a relevant damage pattern.

This situation has triggered discussions at RCAR aimed at specific problems of high-voltage vehicles and their consideration in the evaluation of underwriting risk.

4. Conclusion

From the Allianz claims data, parameters were worked out that have a negative influence on the claims average for BEVs. In the form of presentation chosen for reasons of neutrality, the result for the drive type itself is smoothed. This should not obscure the fact that there are manufacturers who can achieve significant improvements in individual aspects.

Flat-rate replacement solutions for HV batteries based on criteria such as the triggering of airbags (which would affect approx. 2 % to 3 % of all MOD claims) or a general lack of repair solutions still occur in the German market and should be reconsidered by the manufacturers. The protection and ease of repair of components of the HV system and in particular the HV battery is of great importance for the insurance costs of the models.

The AZT study shows that, in addition to the high proportion of comparatively expensive branded workshops, in some cases the workshop system or also the testing regulation for accident-involved HV batteries also drive up costs.

On the design side, it is positive to note that only once did an accident-related intrusion lead to the loss of the battery. On the other hand, clear deficits were found in the protection of the expensive batteries against impact from below.

Also the identified expenses for damaged charging ports in the bumper area (front) are additional costs easily avoidable through suitable design.

The importance of parking and manoeuvring damage is higher for BEV than in the reference group. Here, a greater savings potential can be exploited with suitable ADAS, e.g. according to RCAR's P-AEB standard. The effect of e.g. AEB systems in longitudinal traffic can be considered proven by the study.

Considering the continuously ascending registration figures, it is clear that BEVs will have a rapid increase in the vehicle population and will also arrive in normal individual mobility. The aspects identified here will thus become more visible in the market and hence considerably more relevant for customers than is the case today.