Resource Conservation and Energy Efficiency in Car Production – Sustainability as Part of the Product Strategy

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Abstract

The automotive industry is undergoing radical change worldwide. In addition to the megatrends of digitisation and urbanisation, the government and customers are also increasingly focusing on the sustainability. While the development of alternative drives and their associated energy supply does play a role in this respect, this transformation also affects the entire business model of individual mobility to date. New mobility concepts require innovative products, which also necessitate using materials and resources in different ways. Sustainable efficiency, which must be demonstrated using suitable lifecycle analyses, is becoming one of the KPIs of the future. Electric mobility and increasing lightweight design will substantially increase material costs and the emissions footprint of vehicles and, in turn, reinforce the need for recycling. The circular economy, i.e. setting up closed materials cycles, is therefore becoming a key component in ensuring individual mobility remains affordable. Likewise, carmakers will increasingly have to upgrade their products to create a system, which is networked with its environment and external infrastructures. Development efforts and financial investment must be strengthened in these "peripheral" areas. Aluminium will increasingly be in demand in all these sectors and can remain a material of the future in the car industry given a suitable recycling infrastructure.

Keywords: Automotive, sustainability, circular economy, lifecycle.

1. Sustainability and Life Cycle Assessment

Sustainability is a global megatrend. In particular customers of premium products demand and expect a sustainable product. Governments are also forced to take greater account of environmental factors in legislation. Industry, and in particular the automotive industry, must face up to this change and focus additionally on the product's upstream chain and on its recyclability. Sustainability and conservation of resources are thus part of the Audi strategy and must follow the cradle to cradle vision. In order to achieve these fundamental objectives, we need a suitable tracking tool, the life cycle assessment, LCA.

Within the context of the life cycle assessment, different chains of effect are considered over the entire product life cycle and mutual influences are recognised. The focus of the automotive industry is quite clearly on the reduction of the product's CO2 footprint. The CO2 footprint measures all climate-changing gases and evaluates their impact compared to CO2 as a factor of their intensity. Besides the greenhouse effect, other impact categories are also of relevance, for example the depletion of the ozone layer or summer smog.

Audi sets a very broad framework for the preparation of life cycle assessments. The examination starts with the manner in which raw materials are obtained, and how individual components are manufactured. With respect to vehicle usage, a mileage of 200,000 km is assumed, during which not only the emissions created in vehicle operation, but also those created in the production of the fuel are taken into account. Recycling at the end of the vehicle life is also factored into the life cycle assessment. Figure 1 shows that for a car with combustion engine, manufacturing accounts for around 20% of the total emissions, while recycling is responsible for less than one percent of greenhouse gases. The remaining emissions are created during operation and in the production of the fuel.

Figure 1. Life cycle assessment of a vehicle, including greenhouse gas assessment for a vehicle with combustion engine.

For vehicles with electric drive, manufacturing accounts for a greater proportion of the total emissions than for a vehicle with combustion engine, and this makes it the subject of closer scrutiny. Besides the production of the batteries, which requires a lot of energy, the power station mix for local power generation plays a decisive role in the overall assessment of an electric vehicle. Although the vehicle moves with no local emissions, only power from renewable energy sources has any significant environmental benefit over a vehicle with combustion engine. For this reason, electric vehicles achieve a far superior life cycle assessment than conventional vehicles in countries with a high proportion of power from renewable sources, but an inferior assessment in countries with a high proportion of coal-fired power stations. This demonstrates that future drive technologies and vehicle configurations must be subjected to an integrated examination, meaning the challenge is spread across the entire value-added chain (see Figure 2).

Figure 2. Sustainability must be considered as a whole and implemented along the entire value chain.

2. Materials and Lightweight Construction

The materials used in a car have a major effect on the life cycle assessment. Figure 3 shows the equivalent CO2 emissions created in the production of 1 kg of components made of different materials. The great spread is the result of the different manufacturing processes, supply chains and recycling proportions. Primary aluminium, depending on the manufacturing process and choice of energy source, causes higher emissions than primary steel. Recycled aluminium by contrast causes much lower emissions, on a similar level to those of recycled steel. From an environmental perspective, this makes it especially important to recover the aluminium as comprehensively as possible at the end of the vehicle life cycle. At Audi, recycling thus starts in the production phase, with the collection and recycling of waste scrap in the press shop.

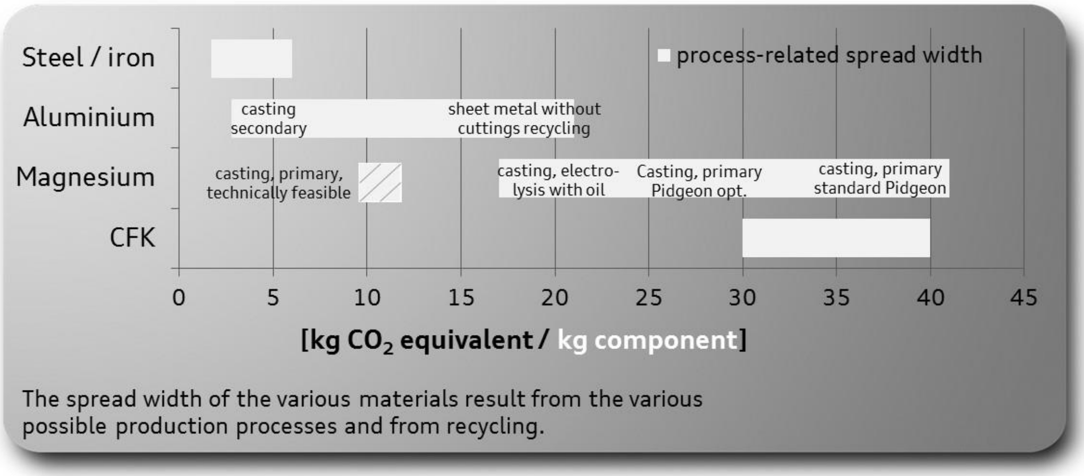

Figure 3. CO_2 emissions created in the production of 1 kg of components made of different materials.

If we consider just the usage phase of a vehicle, the use of lightweight materials is extremely attractive. An Audi Space Frame aluminium body weights about 40% less than a comparable steel body. This leads to a reduction in fuel consumption, resulting in lower emissions during the usage phase.

For Audi, environmentally acceptable lightweight construction means the reduction in CO_2 emissions during the usage phase due to lower vehicle weight is higher than the environmental burden of more energy-intensive manufacturing. It follows that the use of lightweight materials has to overcompensate for the higher emissions created during the manufacturing phase so that ultimately there is a benefit compared to a conventional vehicle concept. Increasing electrification of the power train and the resulting reduction in operation-related emissions mean new challenges from an environmental perspective when it comes to using lightweight materials. The use of secondary raw materials and the closing of material cycles are thus becoming increasingly important and make a valuable contribution to resource efficiency.

3. The Future – The Circular Economy

Increasing digitisation and electrification means we can expect the variety of materials used in vehicles to continue to rise in the future and the material mix to shift towards higher-value materials (see Figure 4). This will also mean a substantial increase in the CO_2 footprint during the manufacturing phase. The recovery of valuable materials and their return to the production process thus becomes increasingly important from both an ecological and an economic perspective.

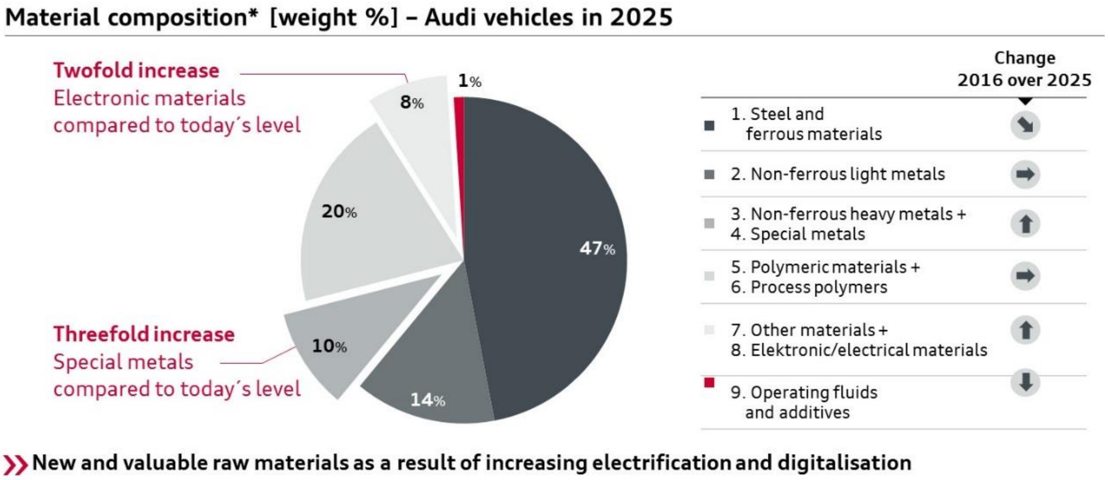

Figure 4. Forecast change in material use due to increasing digitisation and electrification of vehicles.

The focus here is on reversing the emissions spiral along the entire value-added chain and the conservation of resources by increased use of recycled materials. To achieve these objectives, reprocessing, secondary usage and recycling of components must be taken into account together even during the development phase. Furthermore, vehicles must be designed such that the materials used can be recovered as completely as possible and with minimal loss of quality. To this end, the establishment of improved recycling technologies and of corresponding infrastructures are of central importance. These are the essential prerequisites for the implementation of a circular economy in the automotive industry (see Figure 5).

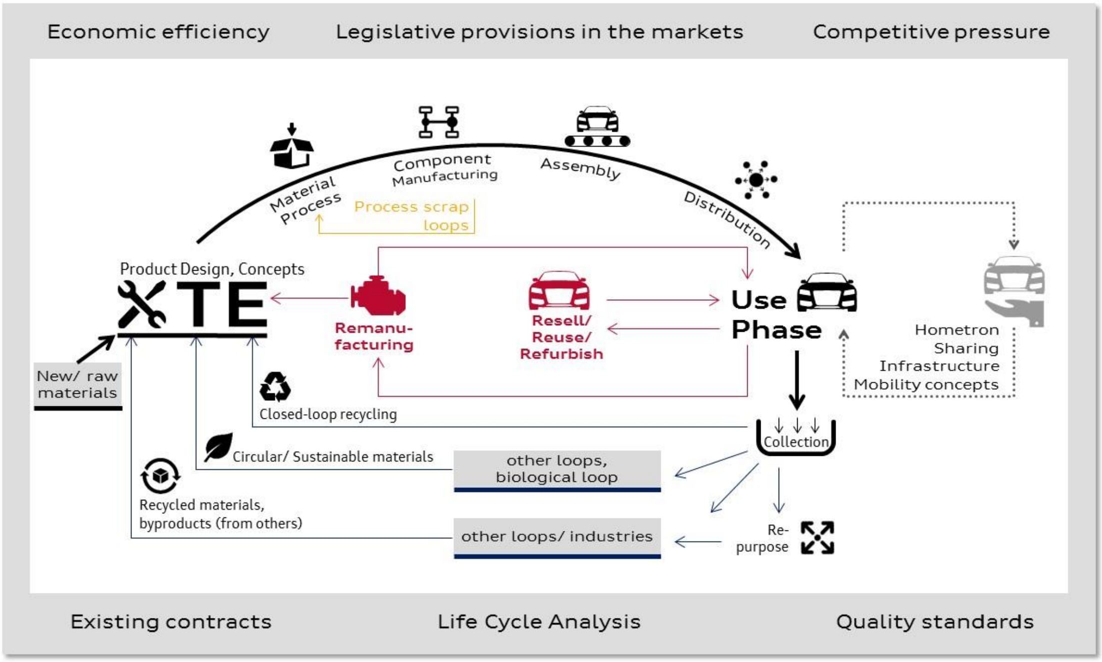

Figure 5. The future – The circular economy in the automotive industry.

A first step in this direction has already been taken with the ALEOL project initiated by Audi. The objective of this project is to develop a recycling process for recovering end-of-life aluminium wrought alloys for use in vehicle bodyshells. Here it has been demonstrated that besides the development of recyclable aluminium alloys, efficient and economical recycling is only realistic with the additional development of suitable separation technologies (see Figure 6).

Figure 6. ALEOL project – development of a recycling process for recovering end-of-life aluminium wrought alloys from vehicle bodies.