Product Life Cycle Assessment - LCA

LED-headlight for cars – P552

This life-cycle assessment of an automotive headlight LED projection module comprises the entire life of a product, from raw material extraction and acquisition, through material production and manufacturing, to use and end of life treatment including recycling and final disposal.

The method for these analyses was an assessment following in principle the international standards ISO 14040 and 14044. Apart from the primary energy consumption, the impact on the environment was evaluated in specific categories. The LCA was calculated with the life cycle modelling software GaBi.

Product description

The P552 is a LED headlight projection module. It was developed for the Ford F-150 (2015). This LCA includes the main components: low beam module, high beam module and the LED driver. The turn signal and parking light module are not considered.

More can be found here: OSRAM P552 LED module for the F-150 (2015)

Electrical and optical data

P552 LED-headlight (components)	Unit	Value
Nominal wattage	W	37
Weight	kg	1.404

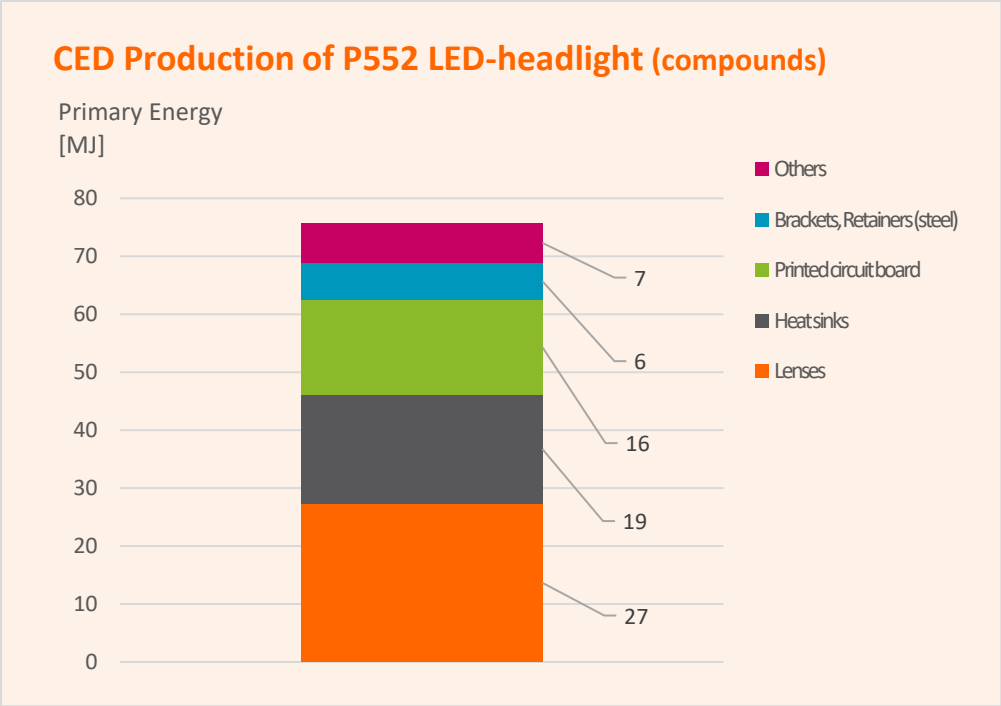
Material composition

The table below shows the material composition of a P552 headlight (components).

MATERIAL	WEIGHT	PERCENTAGE
NON-FERROUS METAL	915 g	65.2 %
POLYCARBOANTE	265 g	18.8 %
FERROUS METAL	159 g	11.4 %
ELECTRONIC COMPONENTS	58 g	4.1 %
SILICONE RUBBER	7 g	0.5 %
TOTAL	**1,404 g**	**100.0 %**

Determining the CED (Cumulative Energy Demand) during the production phase

To determine the amount of energy needed in the manufacturing phase, all the materials used, their masses and production steps are considered. During this phase, transportation of the major components is also taken into account. The cumulative energy demand during the production phase of one P552 headlight is shown in the diagram below.



Calculating CED during the usage phase

Since cars generate their own electricity, the CED of a car headlight during the usage phase is calculated by considering the fuel consumption of the car. In this way CO_2 emissions can also be taken into account. For this calculation an average effectiveness of a generator (0.75) as well as for the combustion engine (0.30) was assumed. As operating time of the lamps, we calculate with a scenario considering usage for 100,000 km. As car fuel the gasoline mix of the German automobile stock was considered.

Average values of operating time of car lamps per 100,000 km:

Light function	Operating time in hours
Low-beam	920
High-beam	50

The values above were collected in an internal study by a German car manufacturer and communicated to OSRAM. OSRAM is not aware of other publicly available studies/data revealing other usage scenarios for car lighting.

1.)	Electrical power consumption, 100,000 km, (HB/LB)[1]	18 W_{El} * 50 h = 0.90 kWh_{El} 18 W_{El} * 920 h = 16.56 kWh_{El}
2.)	Effectiveness (HB/LB)	0.90 * 3.6 MJ_{El} * 4.44 = 14.40 MJ_{El} 16.56 * 3.6 MJ_{El} * 4.44 = 264.96 MJ_{El}
3.)	Fuel consumption/100,000 km (HB/LB)	14.40 MJ_{El} : 32 MJ/l = 0.45 l 264.96 MJ_{El} : 32 MJ/l = 8.28 l

[1] The LED driver module is not considered in this calculation

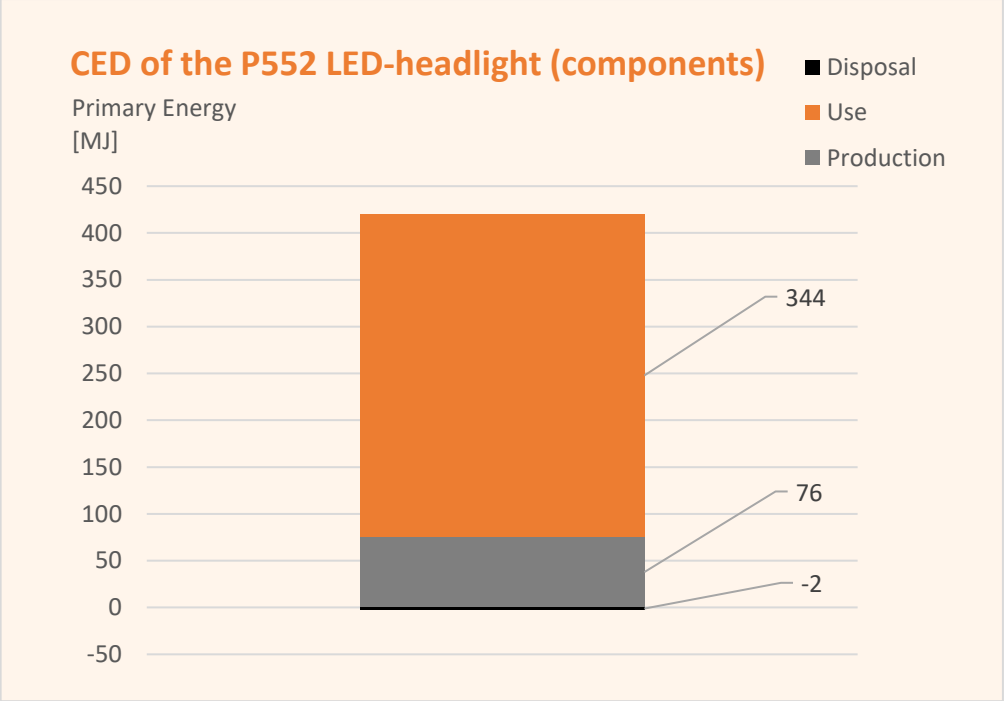
Considering the above fuel-to-power conversion efficiency of a car, fuel consumption and fuel production and distribution, the modelling software calculated the CED within the usage phase of one P552 headlight as 344 MJ_{Prim}.

CED in the disposal phase

In this assessment, incineration of the lenses, PCB and the silicone sealing compounds in a municipal waste-to-energy plant are assumed. This represents the worst-case scenario. Nonetheless, during the incineration process, a small amount of energy can be recovered. A higher amount of energy recovery and further environmental benefits can be obtained by recycling the metal parts of the product.

The CED of the entire lifecycle of LED-headlights

The following diagram shows the results of the entire lifecycle assessment of a P552 LED-headlight. Analysis shows that over 82% of the energy is consumed during the usage phase. In the end-of-life phase, there is a small benefit from energy recovery (-0.54 %) through the re-use of metal components.



Considering that most of the energy consumption occurs during the usage phase, it is strongly recommended to focus on energy efficient systems with a high efficacy (lm/W). Furthermore, with optimizations in the usage phase by improving the efficiency of the system also the highest overall CED savings can be optioned.

Environmental impacts of all lifecycle phases of a P552 LED-headlight

Impact Category	Unit	Production	Usage	Disposal
Cumulative Energy Demand (CED)	MJ	76	344	-2
Global Warming Potential (GWP)	kg CO_2 eq.	4.1	25.0	0.6

Acidification Potential (AP)	kg SO_2 eq.	0.033	0.029	-0.001
Eutrophication Potential (EP)	Kg PO_4 eq.	0.002	0.006	0.000
Photochemical Ozone Creation Potential (POCP)	Kg Ethane eq.	0.002	0.004	0.000
Human Toxicity Potential (HTP)	Kg DCB eq.	2.12	0.81	-0.18
Abiotic Depletion Potential (ADP) (fossil)	MJ	59	325	-2