Product Life Cycle Assessment - LCA

Halogen headlight lamps for cars

This life cycle assessment of halogen headlight lamps for cars comprises the entire life of the product, from raw material extraction and acquisition through material production and manufacturing to usage and end-of-life treatment including recycling and final disposal.

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

Product description

The following report shows the results of LCAs for different types of halogen headlight lamps based on a sample analysis of an ams OSRAM OEM (Original Equipment Manufacturer) long-life H7 lamp. This long-life model is supplied to the automotive industry to be built into new cars headlights. Other models under consideration here are the H1, H4 and H11 long-life lamps. In addition, various combinations are discussed. H7 lamps can be used in car headlights as high-beam and/or low-beam headlights. In comparison, H1 lamps are mostly used for high beam and H11 for low beam only. A special feature of the H4 lamp is that it offers high and low beam in one product because it has two coils.

Electrical and optical data

H7 long-life (OEM)	Unit	Value
Nominal wattage	W	55.0
Nominal voltage	V	12.0
Luminous flux	lm	1,500
Lifespan (Tc*)	h	950
Weight	kg	0.0125
Dimensions	mm	59.0 x 12.0

*Tc lifetime value shows the failure rate of 63.2% of the lamps according to the IEC 60810 standard

Material composition

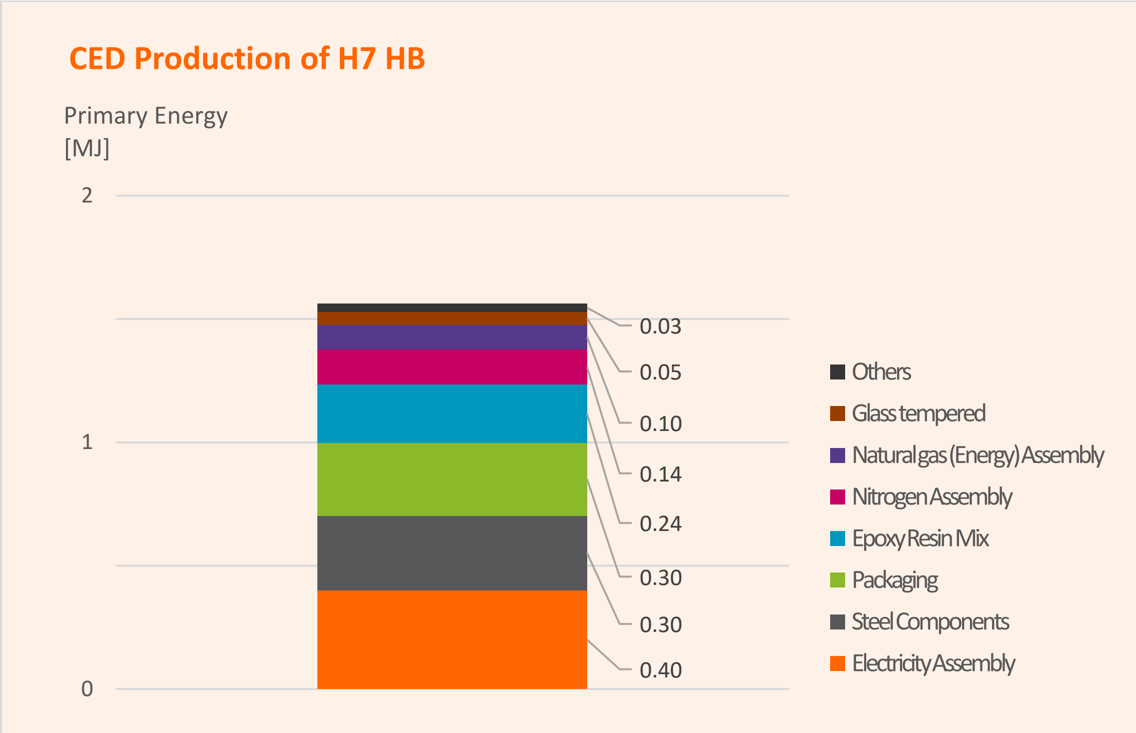
The table below shows the material composition of a H7 lamp including the packaging. Similar materials are used for the other lamps considered in this study.

MATERIAL	WEIGHT	PERCENTAGE
FERROUS METAL	6.6 g	34.8 %
GLASS	3.9 g	20.4 %
RESIN	1.8 g	9.3 %
NON-FERROUS METAL	0.3 g	1.6 %
FILLING GAS	< 0.1 g	0.4 %
PACKAGING*	6.4 g	33.4 %
TOTAL	**19.0 g**	**100.0 %**

*Tray for OEM customer (approximation based on the packaging of an H4 lamp)

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 considered. The cumulative energy demand during the production phase of a H7 lamp is shown in the diagram below.



Calculating CED during the usage phase

Since cars generate their own electricity, the CED of a car headlight lamp during the usage phase is calculated by considering the fuel consumption of the car. Consequently, CO_2 emissions can also be considered. For this calculation, efficiency values for the generator (0.75) and for the combustion engine (0.30) were assumed. For the operating time of the lamps, we based the calculations on a scenario for 100,000 km. The gasoline mix of the German automobile stock was assumed as the fuel.

Average operating times 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 ams OSRAM. ams OSRAM is not aware of other publicly available studies/data revealing other usage scenarios for car lighting.

1.)	**Electrical power consumption, 100,000 km, 50 h (920 h)**	**55 W_{El} * 50 h (920h) = 2.75 kWh_{El} (50.6 kWh_{El})**
2.)	Effectiveness	2.75 (50.6) * 3.6 MJ_{El} * 4.44 = 44 MJ_{El} (809 MJ_{El})
3.)	Fuel consumption for lighting per 100,000 km	44 MJ_{El} (809 MJ_{El}) : 32 MJ/l = 1.37 l (25.27 l)

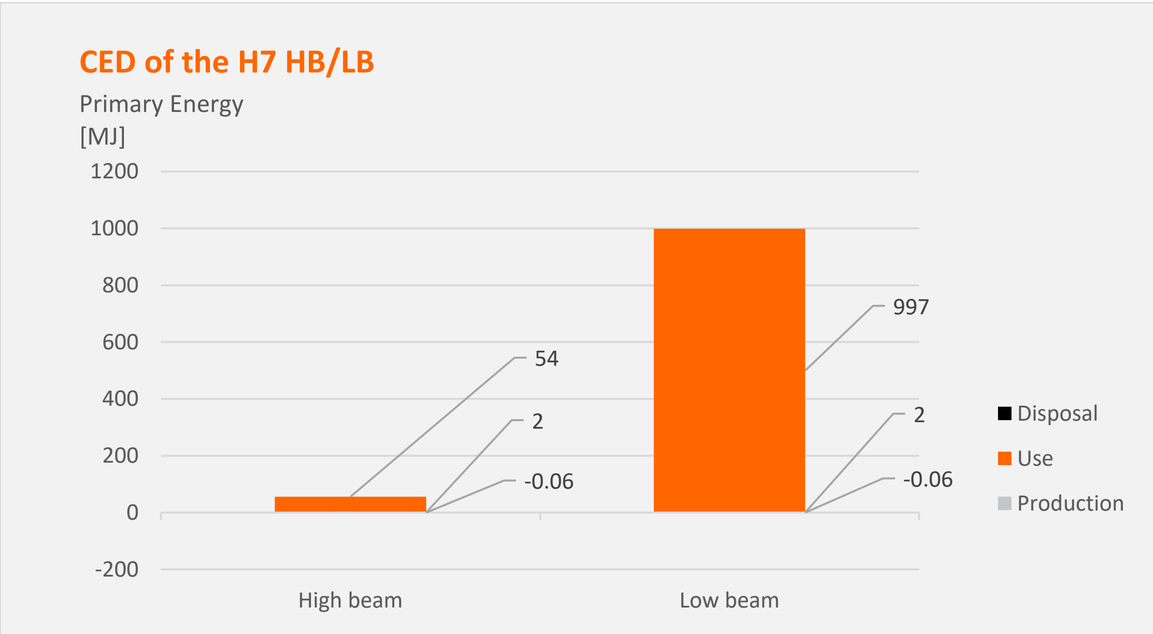
Considering the above fuel-to-power conversion efficiency of a car, fuel consumption and fuel production and distribution, the modelling software calculated the CED within the usage phase of a H7 lamp as 54.2 MJ_{Prim} when operated as high beam and 997.6 MJ_{Prim} as low beam.

CED in the disposal phase

In this assessment, incineration of the packaging of halogen lamps in a municipal waste-to-energy plant and disposal of the glass components in landfill 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 parts of the product.

The CED of the entire life cycle of halogen car lamps

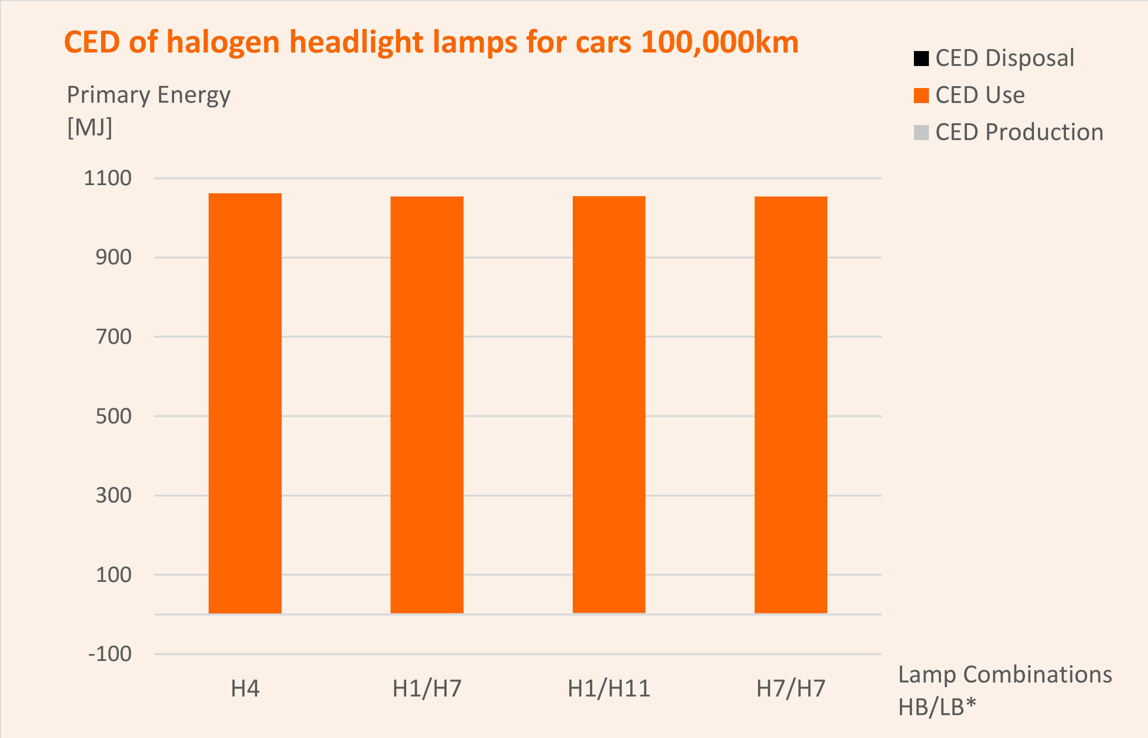
The following diagram shows the results of the entire life cycle assessment of an H7 used as a high beam or low beam lamp. The high-beam analysis shows that over 97% of the total energy consumption occurs during the usage phase (100,000 km) within the car. When used for low beam the value rises to 99%. In both cases, there is a small amount of energy recovery (-0.056 %) in the disposal phase.



Considering that most of the energy consumption occurs during the usage phase, it is strongly recommended to focus on energy-efficient systems with high efficacy (lm/W). Optimizations in the usage phase through improvements in the efficiency of the system can also lead to the highest overall CED savings. This improves the environmental performance and reduces the total impact of the product.

Comparison of CED during the usage phase of different halogen headlights

Depending on the type of headlight mounted in the car, various combinations of halogen lamps are in use. The following diagram shows the CEDs of four different but common combinations. The usage phase is 100,000 km. Even here the usage phase accounts for the largest amount of energy consumed, in some cases >99%.



*HB = high beam, LB = low beam

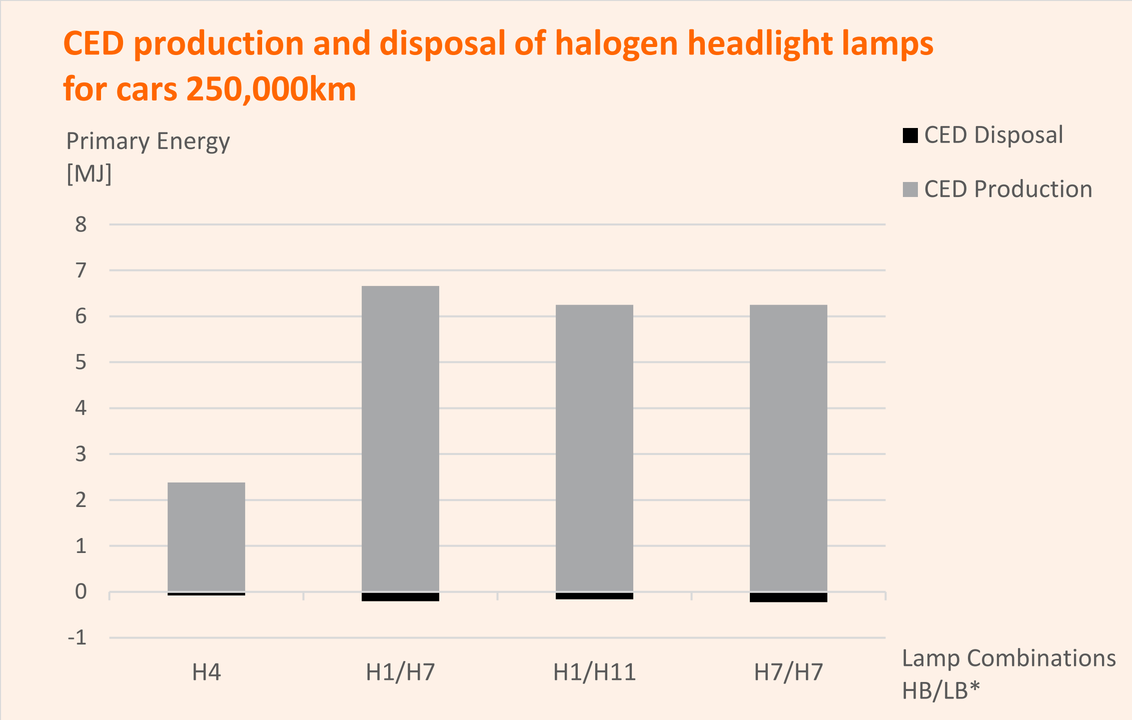
In the graph above we see that the overall CED of the different lamps and lamp combination is very similar if a usage phase of 100,000 km is considered. Nonetheless, the lamp types have different lifespans which matters when considering the lifespan of a car and the replacement lamps needed.

The lifespans of the different halogen lamps are listed in the table below.

Lamp type	Lifetime value Tc [h]
H1 (HB)	1200
H4 (HB/LB)	HB 600 / LB 2400
H7 (HB/LB)	950
H11 (LB)	2000

*Tc lifetime value shows the failure rate of 63.2% of the lamps according to the IEC 60810 standard

The following diagram shows the CED of different car halogen lamps for an assumed lifespan of a car of 250,000 km. Here, lamps are replaced depending on their different lifespans. To better illustrate his, only the production and disposal phase of the halogen lamps are considered.



*HB = high beam, LB = low beam

Here, the analysis is not so uniform anymore. The H4 lamps differ remarkably with less than half of the energy demand compared to the other combinations when considering a lifespan of a car of 250,000 km. This is attributed to the longer lifespan of the H4 lamp and the resulting lower replacement rate.

Environmental impacts of all life cycle phases of a H7 lamp

Impact Category	Unit	Production	Usage – HB/LB	Disposal
Cumulative Energy Demand (CED)	MJ	1.6	54.2/996.6	-0.1
Global Warming Potential (GWP)	kg CO_2 eq.	0.1	3.9/72.3	0.0
Acidification Potential (AP)	kg SO_2 eq.	2.6E-04	4.6E-03/8.4E-02	-3.1E-05
Eutrophication Potential (EP)	Kg PO_4 eq.	2.5E-05	9.3E-04/1.7E-02	-1.6E-06
Photochemical Ozone Creation Potential (POCP)	Kg Ethane eq.	1.5E-05	5.8E-04/1.1E-02	-1.7E-06
Human Toxicity Potential (HTP)	Kg DCB eq.	0.03	0.13/2.34	0.00
Abiotic Depletion Potential (ADP) (fossil)	MJ	1.1	51.2/942.2	0.0