



Requirements on Lighting (Light Intensity) and Reflectors of Bicycles

ADFC Allgemeiner Deutscher Fahrrad-Club, European Cyclists' Federation, and Fietsersbond NL

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Executive Summary

There is sparse information or research on cycling accidents, safety and bicycle lighting. The report did find that many cyclists do not have functioning lights during times of darkness. Although there are often absolutely more accidents/casualties during the day, it is *suspected* that there will be relatively more accidents/casualties at night, however exposure figures are necessary in order to say conclusively. One known study that takes into account exposure figures came from the Netherlands which did conclude that night cycling was relatively more dangerous at night. However this was based on a country with a very high cycling modal share (25-35%) and could not be said to be representative of Europe. Confounding figures such as alcohol could also play a large part in night time accidents. Road safety and use of bicycle lighting in the EU are inconclusively linked.

Regarding traffic regulations and bicycle lighting there seem to be as many regulations as there are countries, and as far as we can tell there is only one country (the UK) whose traffic regulations refers to a bicycle lighting standard. The current market for bicycle lights is still very broad and includes different lamps, power sources, lights etc. A standard would have to incorporate all different types of lights, including their many idiosyncratic problems. We believe that this is possible and we have put forward suggestions based on the German DIN 33958, the new Dutch Dekra NL standard and the draft ISO draft standard currently being updated. If a standard were to be introduced it should be of a good enough quality to not bring about de-regulation in those countries with a high standard (e.g. Germany). If a country wished to have lesser standard lights it would deregulate or make reference to the light in its traffic regulations. One problem could be if a country decides to insist on lights being placed on a bicycle at manufacture or sale, this may increase prices in countries where a bicycle costs less than in those countries with a highly developed bicycle market; this could stunt the growth of the bicycle. Most cycling organisations seemed to think that a standard would be a good idea with the following provisos

- The standard must be flexible enough to cope with the myriad forms of lighting around Europe
- Too much complexity could drive away some, and could lead to the loss of perfectly good lights being accepted
- If the standard is too geared towards expensive lights then perfectly good cheaper lights could leave cyclists liable even if their lights are perfectly good
- A too high standard tied to regulations could mean problems in countries where bikes cost 200-300 Euros if the lights cost 10-15% of the total bicycle price
- Too low a standard would have less effect on road safety and would mean de-regulation in those that have high standards
- Criticism of how ISO are currently dealing with battery lights by making them too design restrictive

We also provided possible suggestions for information for the consumer to be a part of the standard. The report found that reflectors only really work at short distance and in the presence of a strong incoming light, as a single measure they are not really effective though should be encouraged as a possible emergency fall-back.



Accident statistics - Survey and analysis of scientific information on accident data involving cyclists

The importance of bike lights in accidents

There is not a great deal of literature on cycling safety, lighting conditions and bicycle lighting. In this section the report puts forward a literature review of what is available to attempt to paint a picture of the level of risk for cyclists in adverse lighting condition. The report looks at

- numbers of cyclists using lights
- The report tries to ascertain links between cycling in adverse lighting conditions and casualty/accident figures
- Whether there is cause between lighting deficiencies and casualty/accident figures

These figures are extremely difficult to come by and are nowhere explicitly stated in a report or published study, we have then used what literature and evidence there is.

Proportion of cyclists without active illumination

Bicycle lights have made significant progress in recent years. Halogen or LED bulbs are not as vulnerable as bulb lights which often become defective. However, even in countries where the bicycle is an everyday mode of transportation, and are often ridden during the evening or at night, relatively few cyclists travel on the road with proper lighting. According to a Swiss study about a third of cyclists ride with no functional lighting and 17% without lighting at all¹. In a sample of a Swedish university town of 896 cyclists 72% had no lawful lighting². In Germany, nearly 40% of cyclists ride in the dark with poor lighting or without any lighting at all³. These figures were confirmed by regional samples of the German Cyclists' Federation ADFC in Tübingen and Nürnberg in November 2009⁴ and backed up by studies from

¹ Walter E, Cavegn M, R Allenbach Scaramuzza G. bicycle traffic - Accidents Risk Factors and Prevention. Bern: BFU - Swiss Council for Accident Prevention, 2005

² Setiawan, Pitra. The use of lights on the bicycles: cyclists' perception on safety - a case study in Lund. Lund, Sweden 2009

³ <http://www.dvr.de/aktuelles/sonst/1422.htm> These figures were found in eleven cities by the German automobile club ADAC in 2009

⁴ <http://www.adfc.de/verkehr--recht/aktiv--vernetzt/adfc-radverkehrs-news/adfc-radverkehrs-news---archiv/rv-news-basis-2010/adfc-radverkehrs-news-20101>



Switzerland and Austria⁵. Research from 2005 shows that 63% to 65% of cyclists have a light; i.e. 35% to 37% are without lighting⁶.

On the other hand, this is not just confined to the bicycle, in Germany, defective or badly adjusted lights are found to be the most common malfunction in motor vehicles tested for roadworthiness. According to an evaluation by the TÜV Report 2008⁷, more than a third (35.6%) had minor or significant deficiencies in the lighting system. Inspections carried out by workshops of the German traffic safety organisation Deutsche Verkehrswacht each year in October show that over 35% of drivers are traveling with improper illumination. This is a very similar number as for the bike lights. A high degree of redundancy in automotive lighting⁸ results in a 50% failure of the entire lighting system. For bicycles only the reflectors of the bicycle provide some compensation for the frequent loss of active lighting.

Night accidents of cyclists in Switzerland and Germany

If we take figures from the Swiss Council for Accident Prevention (CAP)⁹ we see that at night there are a disproportionate number of bicycle accidents.

Only about 10% of bicycle trips are taken at night, whereas about 20% of bicycle accidents occur at this time¹⁰. However, accidents at night can be caused by factors other than the light conditions, such as the influence of alcohol (by cyclist or other road users). Alcohol consumption often takes place at night rather than during the day and brings an increased accident risk. In Germany only 9% of all traffic accidents in 2010 occurred between 22.00 and 06.00, but nearly half of the total was alcohol-related accidents.¹¹

The Federal Statistical Office of Germany (Destatis¹²) publishes annually a summary of the official accident statistics. In 2011 on German roads 399 cyclists were killed, looking at both accidents in town or out of town and in daylight, dusk and at night¹³.

⁵ Scherer C, Ewert E. functionality and use of bike lights in Switzerland 1995/1996. Bern: BFU - Swiss Council for Accident Prevention, 1996

⁶ Reurings, Hoe gevaarlijk is fietsen in het donker? (How dangerous is cycling in the dark?), SWOV 2010

⁷ <http://www.presseportal.de/pm/38751/1468663/beleuchtung-an-autos-ist-haeufig-fehlerhaft-lichttest-bei-tuev-nord-mobiltaet>

⁸ the main lights to the front and back of the car are in pairs and are backed by position lamps, this prevents their malfunction of a single light bulb, as is the case with German bicycle lights

⁹ Walter E, Cavegn M, R Allenbach Scaramuzza G. bicycle traffic - Accidents Risk Factors and Prevention. Bern: BFU - Swiss Council for Accident Prevention, 2005

¹⁰ Ibid.

¹¹ <https://www.destatis.de/EN/Homepage.html> page 10

¹² <https://www.destatis.de/EN/Homepage.html>

¹³ In relation to bicycle lighting we must also include the fatal accidents at dusk and dawn



This study found that in 2011, in adverse visibility conditions 68 cyclists were killed (17% of all deaths), including 34 urban cyclists (9 at dusk, 25 at night) and 34 outside urban areas (4 at dusk, 30 at night). In daylight there were 205 urban cyclist fatalities and 126 cyclists killed outside urban areas; 331 in total. This is a ratio of 38% fatalities in adverse darkened conditions to 62% fatalities in daylight conditions.

What is also striking in the German road accident statistics is the equivalent number of dusk and night fatal bicycle accidents in both cities *and* outside the city, both at 34, striking because the vast majority of cyclists can be found in cities. In 2009 in Germany there were 75,797 cyclists accidents, including 68,435 urban and 7362 suburban; 462 were fatal. Of these, 259 died in town and 203 out of town. On rural roads there are only 10% of bicycle accidents involving injuries or fatalities, but they account for 44% of the deaths. In 2009 of the 259 urban cyclist fatalities 38 (15%) were killed in dark conditions while of the 203 outside urban areas fatalities 39 were in dark conditions (19%). Of the 239 killed in 2011 in urban areas, 34 (14%) were killed in twilight or darkness, while for the out of town fatalities (160 in total) 34 were killed at night (21%). *The risk of suffering a fatal accident outside of urban areas is thus several times higher (10% of accidents, 44% of deaths) compared with urban accident and increases again in twilight or darkness by up to 50%. The majority of fatal bicycle accidents occur also on country roads outside of urban areas during daylight hours. The more severe consequences of accidents during the day or at night are likely to be largely due to the high vehicle speeds in the extra-urban traffic.*

The official road accident statistics in Germany shows "accidents and casualties and lighting conditions" for 2011 for all road users giving the following figures:

- Injury accidents total 306,266,
- Of which during daylight 229,391 (74.9%),
- Of which at dusk 15,304 (5.0%)
- Of which during the night 61,571 (20.1%)
- For twilight and darkness together this amounts to (25.1%)

4,009 people were killed

- Of which during daylight 2552 (63.6%),
- Of which at dusk 187 (4.7%)
- Of which during the night 1270 (31.7%),
- For twilight and darkness together this amounts to 36.4%.

So with respect to all road users traffic accidents in dusk and at night bring worse consequences accounting for one quarter of the casualties, but more than a third of those killed.

Based on 2011 figures the numbers of fatally injured cyclists at dusk and at night were 17%, in 2010, the percentage was 19.5%. These figures from Germany are close to the calculated value for Switzerland, 20% night time bicycle accidents, and suggest a significantly increased risk for cyclists in twilight or darkness, both in terms of the probability of accidents and the severity of the accident. However due to the lack of



known exposure data in Germany (such as number of trips, or km travelled etc.) definite statements about the extent of the increased accident risk cannot be identified.

Many cyclists will not cycle in the dark. In Germany, the bulk of the accidents occur in the summer, on days with short hours of darkness. An evaluation of the Berlin bicycle accidents in 2010 found the following figures¹⁴:

- From 6:00am accidents start to pick up and increase constantly.
- The accident peak is reached between 15:00 to 15:59.
- The hours between 16:00 to 18:59 have a similar, almost uniformly high number of accidents.
- A fall in accident numbers occurs from 21:00.
- In the summer months, accidents are frequently reported well into the late evening.
- In the autumn and winter months, the number of accidents drops sharply at the latest from 20:00

In big cities like Berlin still with a high cycling modal share in autumn and winter, many people will cycle even at dusk and dawn, for instance on their way to school or work. School and commuter traffic tends to vary less with the seasons (i.e. to be more steady over seasons) than leisure traffic. A statement as to whether the proportion of bicycle accidents in the dark corresponds to the share of cycling during the dark times of the day is not possible, however, because data on the distribution of cycling over 24 hours are not available for Berlin or Germany.

Cyclist fatalities during darkness or twilight in the EU

Monthly data

Data from the EU is available for the distribution of cyclist fatalities per month and by hour of day¹⁵. From the CARE Database 37% of cyclist fatalities in 2009 in the EU-23 countries occurred in July, August and September. The proportion of cyclist fatalities during January, February and March is only 14 %. This is less than the proportion of car occupant fatalities during these months of 24 %. There is no clear trend in the incidence of cyclist fatalities by month in individual countries. The peak for the EU-23 countries occurred in July (13 %) and the fewest fatalities occurred in January (6 %)¹⁶.

¹⁴ Polizeipräsident Berlin -Police Headquarters Berlin-, Sonderuntersuchung Radfahrerverkehrsunfälle in Berlin 2010, <http://www.berlin.de/imperia/md/content/polizei/strassenverkehr/unfaelle/statistik/radfahrer2010.pdf?start&ts=1300366029&file=radfahrer2010.pdf>.

¹⁵ http://ec.europa.eu/transport/road_safety/pdf/statistics/dacota/bfs2011_dacota-swov-cyclists.pdf

¹⁶ Ibid. Page 6



Again, the actual number of cyclists on the road in summer (with short hours of darkness) and in winter is not known. Given that there will be more cyclists during these times this probably explains the higher accident numbers in summer. Also slippery wet conditions of many European winters may contribute to high-severity accident injuries, independent of the lighting conditions.

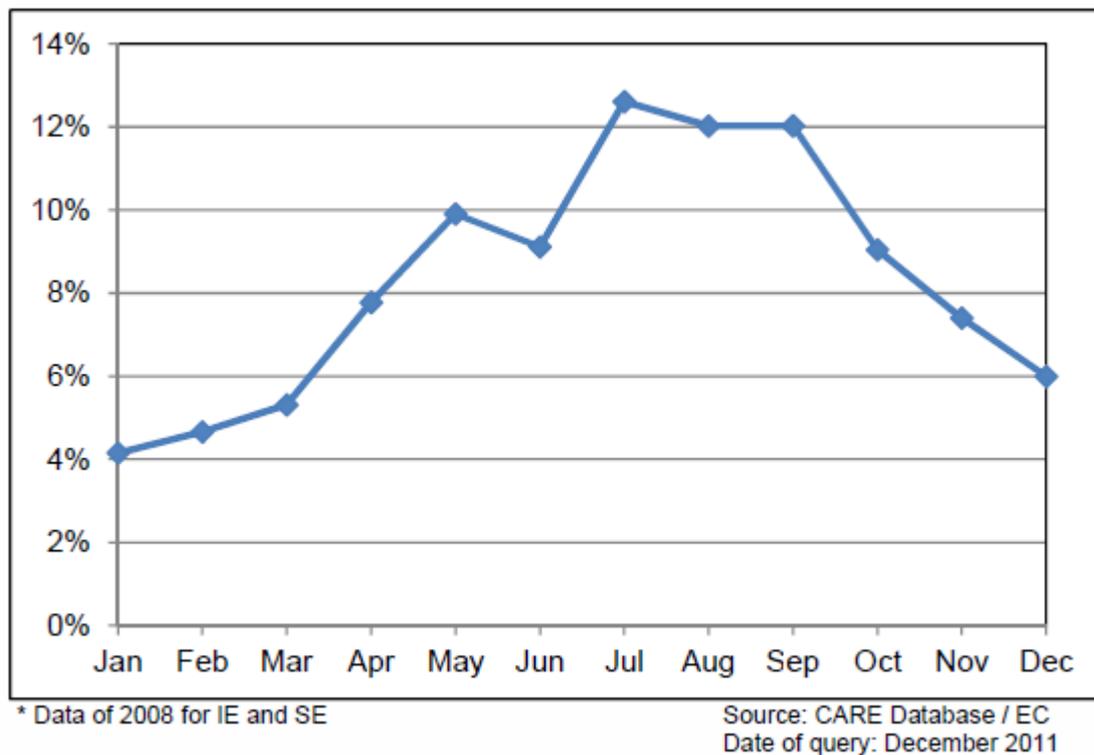


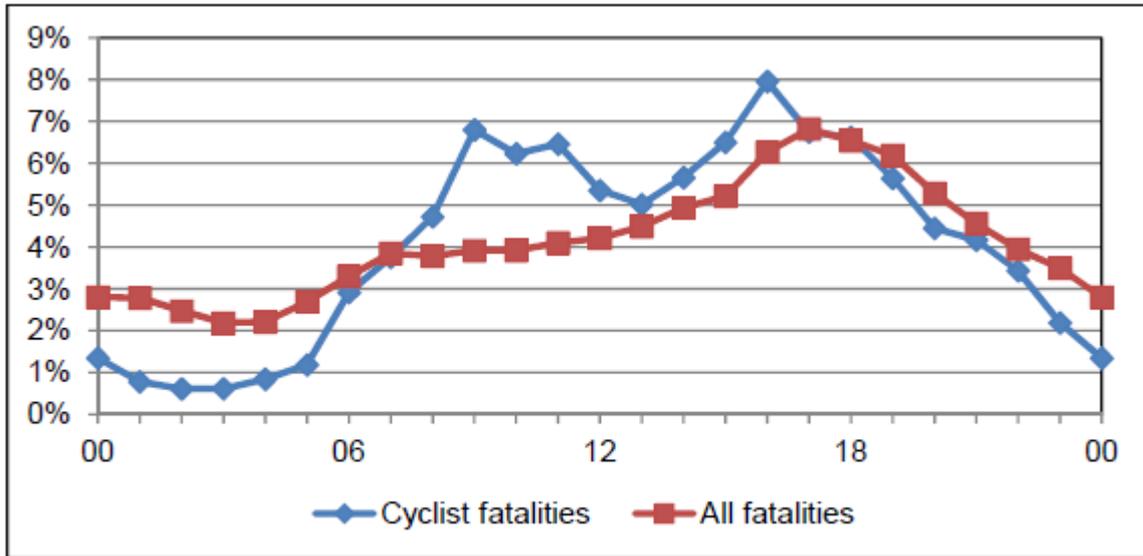
Figure 1: Proportion of cyclist fatalities per month in 2009, EU-23 (DaCoTa Figure 417)

Daily data

The next figure presents the distribution of cyclist fatalities over 24 hours for the EU-22 countries. A large percentage occurred during the 16:00-20:00 hours' time period (27 %). Also between 08:00 and 12:00 and 12:00-16:00 hours, more cyclists are involved in fatalities (24 % and 23 % respectively) than during other times of the day. Compared to other modes of transport, the share of bicycle fatalities raises during the day. There is no clear trend for individual countries, for example: the fatality proportion between 4:00 and 8:00 was slightly above average in Denmark and Sweden; between 8:00 and 12:00 it was above average in Spain and the UK¹⁸.

¹⁷ http://ec.europa.eu/transport/road_safety/pdf/statistics/dacota/bfs2011_dacota-swov-cyclists.pdf Page 6

¹⁸ Ibid. Page 8



* Data of 2008 for IE and SE

Source: CARE Database / EC
Date of query: December 2011

Figure2: Distribution of cyclist fatalities and of all road fatalities by hour of day in 2009, EU-22 (DaCoTa Figure 5)

Light conditions data

The role of light conditions on the incidence of cyclist fatalities is demonstrated in figure 3. Some of the fatalities between 16:00 and 20:00 hours may be related to lighting conditions: around 25 % of accidents happened in the dark. Accidents between 08:00 and 16:00 hours have few fatalities related to darkness, and relatively few to twilight¹⁹. These are the daylight hours, with the highest proportion of fatal cyclist accidents.

¹⁹ Ibid. Page 8

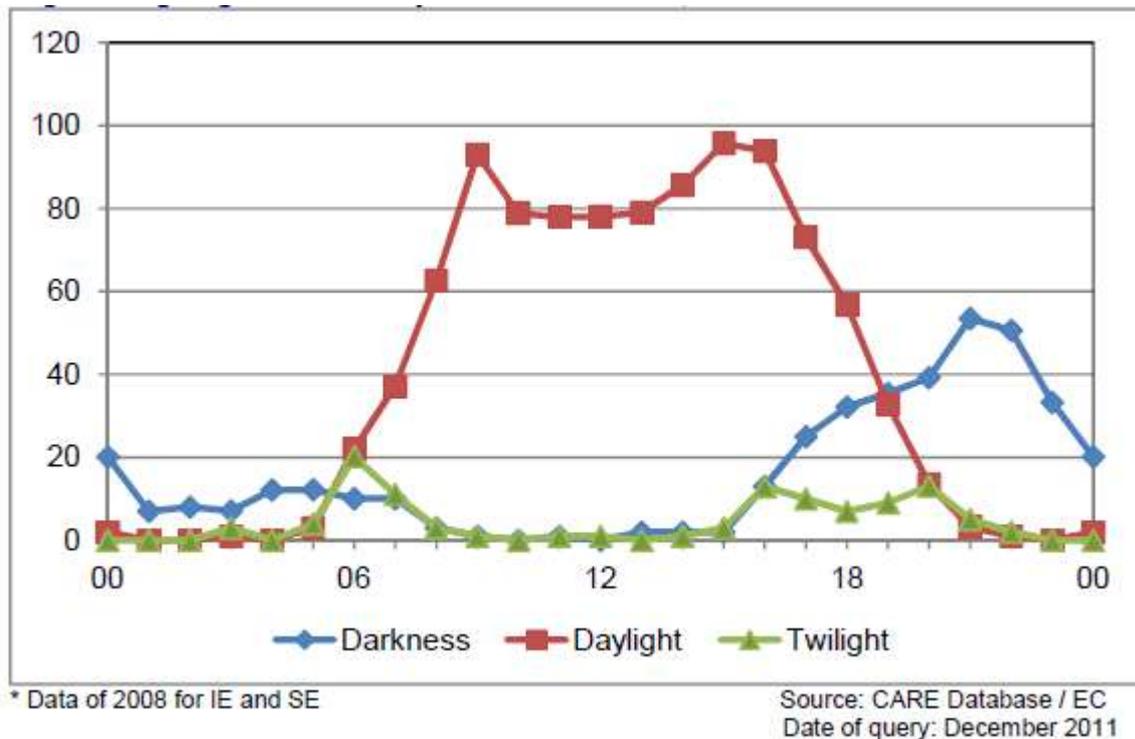


Figure3: Lighting conditions for cyclist fatalities in 2009, EU-22 (DaCoTa Figure 620)

According to the number of cyclist fatalities in the EU-21, a share of about 20 % for fatal accidents during darkness or twilight is typical of countries like Germany, France, the Netherlands and Sweden. Switzerland as a non-member is not included in these statistics though it has a share of about 20 % as well. The average for the EU-21 in 2009 was 30 %. The range is from 15 % in Finland to 52 % in Portugal and even 100 % in Ireland²¹. Among the larger countries, the proportion was around 40 % in the Czech Republic, Hungary, Poland and Romania.²²

²⁰ Ibid. Page 9

²¹ Due to the low casualties in absolute figures

²² http://ec.europa.eu/transport/road_safety/pdf/statistics/dacota/bfs2011_dacota-swov-cyclists.pdf Page 10



	Darkness	Daylight	Twilight	Number known	Total	% dark or twilight
BE	17	69	3	89	89	22%
CZ	29	48	7	84	84	43%
DK	4	21	0	25	25	16%
DE	77	366	19	462	462	21%
EE	3	4	-	7	7	43%
IE	13	-	-	13	13	100%
EL	8	6	1	15	15	60%
ES	13	38	5	57	57	33%
FR	26	128	8	162	162	21%
LV	11	13	2	26	26	50%
LU	1	1	-	2	2	50%
HU	42	61	-	103	103	41%
NL	24	110	3	137	138	20%
AT	9	29	1	39	39	26%
PL	96	226	49	371	371	39%
PT	13	14	2	29	29	52%
RO	42	91	24	157	157	42%
SK	4	15	0	19	22	21%
FI	2	17	1	20	20	15%
SE	5	21	1	27	30	22%
UK	24	80	-	104	104	23%
EU-21	463	1357	127	1947	1.954	30%

* Data of 2008 for IE and SE

Source: CARE Database / EC
Date of query: December 2011

Table1: Number of cyclist fatalities by lighting conditions in 2009, EU-21 (DaCoTa Table 723)

A major problem is that the CARE Database does not give exposure figures, i.e. the number of cycling trips, or km travelled etc. during dark. However the fact remains that almost one-third of killed cyclists (30 %) in the EU-21 countries were killed when lighting was poor. Even if the number of cyclists on the road over 24 hours is not known for these countries we can assume that this share exceeds the proportion of cycling trips taken in twilight or darkness by far. This share is about 10 % in countries in which the bicycle is a part of everyday transport (like Switzerland and even more so the Netherlands) and can be assumed to be lower where cycling is mainly a leisure activity for which daylight is preferred.

²³ Ibid. Page 10



Seriously injured cyclists in night time crashes in the Netherlands

A recent study from the Netherlands²⁴ states that there has been no previous research in the Netherlands into how dangerous it is for cyclists to ride their bikes in the twilight and by night (this is also true for the rest of Europe). It says that this is one of the reasons why it cannot yet be determined how much bicycle lighting generally contributes to road safety, in other words, how many casualties it saves among cyclists. The main difference between the figures given in this Dutch study and those for Germany and other EU members reported so far is that exposure (distances travelled by bicycle or number of trips) under different lighting conditions was taken into account because of the Dutch/SWOV data on the daily mobility of cyclists. Dividing the number of casualties by the distance travelled by bicycle (in millions of kilometres) gives the casualty rate for each light condition: the higher the rate, the more casualties per kilometre travelled.

Also included in the study are analyses of serious (road) bicycle injuries as well as fatalities. Furthermore, casualties among cyclists are distinguished between casualties in crashes involving a motorized vehicle and casualties in crashes with no involvement of a motorized vehicle.²⁵

In terms of absolute figures "most of the seriously injured cyclists accidents were involved in daylight crashes, both those involving and those *not* involving a motorized vehicle."

This is expected as there are more cyclists during the day. But during the night there are *relatively* more casualties among cyclists than in daylight hours

"During the period 1993-2008, the percentage of cyclists who were seriously injured in motor vehicle crashes in the dark fluctuated between 14% and 17%. For seriously injured cyclists in crashes *not* involving motorized vehicles the percentage increased from 13% in 1993 to 23% in 2008. However, only 10% of the distance cycled is travelled in the dark, which allows the conclusion that casualty rate for cyclists is higher in the dark than in daylight."

These figures also seem to be rising;

"For seriously injured cyclists in crashes without motorized vehicles being involved, the early morning casualty rate in the dark in 1993 was a factor of 4 higher than in other light conditions, and in 2008 this was a factor of 10 higher. This casualty rate shows an increase by a factor of 2.6 for the period 1993-2008."

The study also looked across age ranges and light conditions, concluding;

²⁴ Reurings, Hoe gevaarlijk is fietsen in het donker?, SWOV 2010. www.swov.nl/rapport/R-2010-32.pdf

²⁵ Reurings, Hoe gevaarlijk is fietsen in het donker? (How dangerous is cycling in the dark?), SWOV 2010



"...the casualty rate is higher in the dark than it is in daylight because cycling in the dark is indeed more dangerous and not because those cyclists travelling in the dark have an increased casualty rate in all conditions. Especially for those in the age group 18-29 year-old in particular it is dangerous to cycle in the dark (compared to their overall casualty rate)."

A major problem still is selecting out confounding factors such as alcohol use

"There are, however, clear indications that it is not only the dark, but also the use of alcohol which plays a crucial role in the high casualty rate for this group. In 1993, 24% of the 18-24 year-old cyclists who were seriously injured on a weekend night in a crash without motorized vehicles being involved had used alcohol (according to information in the hospital registration); this increased to 58% in 2008. Also among the 25-59 year-olds alcohol use is relatively high and increasing: 21% in 1993 and 44% in 2008."

Other confounding factors can be weather conditions and slippery roads that are associated with dark times. The report did indeed find this to be the case in accidents with motorised vehicles but found that "...the casualty rate for cyclists in *non*-motorized vehicle crashes, on the other hand, is highest in *summer*"

However we do have to be careful before we extrapolate this EU wide as the Netherlands is a special cycling case (the number of cycling solo accidents perhaps illuminating this). However 10 % is also the same as the share given for Switzerland,²⁶ in spite of the obviously different cycling culture in both countries.

Technical deficiencies or lack of bike lights as cause

The relationship between using bicycle lights (and their quality) and the casualty rate when cycling in dark and dusk very is difficult to investigate, because it is not known whether or not cyclists who were involved in a crash had working lights on their bicycle, and was not even studied specifically in the SWOV/ Reurings study.²⁷ This is confirmed in another Dutch study published in 2008 which points out that no literature in English, Dutch or German could be found on the relation of bicycle lighting and traffic safety²⁸.

²⁶ Walter E, Cavegn M, R Allenbach Scaramuzza G. bicycle traffic - Accidents Risk Factors and Prevention. Bern: BFU - Swiss Council for Accident Prevention, 2005

²⁷ Reurings, Hoe gevaarlijk is fietsen in het donker?, SWOV 2010. www.swov.nl/rapport/R-2010-32.pdf

²⁸ TNO-rapport TNO-DV 2008 C238, Vergelijking van fietsverlichtingsvormen - Comparison of Types of Bicycle Lights http://www.fietsberaad.nl/library/repository/bestanden/Eindrapport_Fiets_verlichting.pdf



It is however possible to find data on the technical deficiencies, or lack of lights, as a cause of an accident²⁹. Information on technical defects (here: the lighting defects) as an accident cause could not be found for the EU as a whole, but could be found in some individual countries. In the German Federal Statistical Office report of 2011³⁰, technical defects were attributed to four bicycle fatalities the main cause of which could be put down to defective lights. Therefore defective lighting is considered the most common technical defect which led to a fatal accident. However considering the total number of bicycle fatalities of 399, bicycle fatalities due to defective lights are 1%. In accidents involving personal injury, the proportion of accidents due to defective lights of bicycles is only 0.7%.³¹ Then the defective lights of bicycles had only a minor role for the accident. However since defective lighting accidents only occur in darkness or twilight, it is appropriate that bicycle accidents with defective lights are seen in relation to only those accidents in darkness in twilight; 4 out of 68 (in dusk and dawn) 5.9%, and 4 of 55 (in the dark) 7.3%.

This percentage is comparable to figures given by the Swiss BFU. In their safety dossier, they speak of 4% bicycle accidents due to defective lights. Because the number of cyclists riding at night is much smaller than during daylight hours, the share of victims of accidents without lights is not negligible (or marginal) any more when related to the trips taken during periods of darkness.

The above figures are derived from police reports from the scene. So a problem is often that for the police officer, it is not always detectable with certainty whether the technical deficiency was an important cause of the accident. The same applies to the statement of the cyclist who would often prefer to distract the authorities from his misconduct by presenting the technical fault as the cause of the accident³². In other words this is very much open to charges of under reporting but also over reporting.

SWOV study, bicycle lighting, research needs

The SWOV study³³ did not systematically investigate the possible explanations for the higher rates during dusk and dark. A first recommendation was to develop policies to discourage 'cycling under the influence' (p. 56). The link between the use of bike lights (and their quality) and the risk of cycling in twilight and darkness mentioned in the SWOV report has also not been studied. It is difficult to study, says the report, because it is not known whether the cyclist crashed in a bicycle light related

²⁹ This is not the same thing as looking at the relationship between the *use* (and quality) of bicycle lights and the casualty rate, rather this looks at the *non-use* of bicycle lights

³⁰ Federal Statistical Office, (2012). Traffic accidents - Two wheeler accidents on the road 2011th Wiesbaden, Germany

³¹ <https://www.destatis.de/EN/Homepage.html> 2011 report

³² Walter E, Cavegn M, R Allenbach Scaramuzza G. bicycle traffic - Accidents Risk Factors and Prevention. Bern: BFU - Swiss Council for Accident Prevention, 2005

³³ Reurings, Hoe gevaarlijk is fietsen in het donker?, SWOV 2010. www.swov.nl/rapport/R-2010-32.pdf



accident³⁴. Although well-known in annual censuses, the proportion of cyclists who cycle at night with lights is fairly constant since 2005 (63 - 65%).

Generally night-time accidents result in more severe injuries. Higher vehicle speeds due to empty roads at night, a higher number of drivers under the influence of alcohol with deficits in vision and reaction and the problems of elderly drivers with night vision impairment all contribute to this. According to estimates from German experts in traffic medicine, one in seven motorists is affected by 'night blindness'. Working bicycle lights enable these high-risk drivers to perceive and recognize cyclists better (and earlier) and give them the opportunity to respond in time to avoid a collision. This is also true for motorists with normal vision as the visual performance of the human eye at night generally drops to 5 % of the daytime value.

In daylight, in good visibility and with good eyesight a cyclist or a pedestrian is seen from several hundred yards away. At night it is very different: The high beam is designed so that the illumination is about 150 meters. The low beam however must not blind oncoming traffic which brings the visibility down to about 40 to 70 meters (braking distances for cars at speeds of 70 - 80kph are approximately between 50 - 80 metres depending on road conditions).

BFU and Switzerland: Fixed versus plugged lighting

Fixed lighting provision (fixed on the bike as opposed to being detachable) was abolished in Switzerland on 1st February 1994. Currently bicycles must have at least a white (in front) and a red (behind) static light, these must be seen from 100m, they may be fixed or removable and the lights must not dazzle oncoming traffic.³⁵ The Swiss Council for Accident Prevention (CAP) periodically examined the light rates of Swiss bicycles and the progression of cycling accident figures. In its report of 1996³⁶, the BFU states that only 50% of cyclists rode at night with proper lighting and one-third are completely without lighting. Moreover, the number of injured cyclists aged 15 - 19 years old in the dark as a proportion of number of accidents rose from 19.5% in 1992 to over 21 in 1994.

If fixed lighting was on the bicycle it was found to be broken in about 25% of cases, the main defect being a failed bulb (40%), followed by defective cables (25%). More recently with the rise of LED lighting as the state of the art, defects of the light bulb may be increasingly eliminated. Therefore technical defects can be eliminated as the main reason for lightless trips. Rather, in most cases there are no lights on the

³⁴ "Dit is ook moeilijk te onderzoeken, omdat niet bekend is of de fietsers die betrokken zijn bij ongevallen al dan niet licht voerden"

³⁵ Walter E, Achermann, Striker Y, Scaramuzza G, Niemann S, M. Cavegn bicycle traffic. bfu safety Dossier No 08 Bern: BFU - Swiss Council for Accident Prevention, the 2012

³⁶ Scherer C, Ewert E. functionality and use of bike lights in Switzerland 1995/1996. Bern: BFU - Swiss Council for Accident Prevention, 1996



bicycle.³⁷ The authors came to a similar conclusion in 1996 by proving that permanently fixed lights had a higher rate of use than detachable lights. Accordingly, cyclists ride more often with their lights on in the dark if these are permanently attached to the bike (as with dynamo-driven lighting) than if the lights are detachable such as battery lights³⁸.

In the current road safety dossier of 2012 BFU gives visibility a high potential for road safety. Even though better visibility alone would not prevent single accidents, a large part of the collisions with other road users could be avoided, even in daylight. At night, the use of bicycle lights would have to be increased significantly. Likewise, more reflectors must be used. The authors want to implement this in particular by raising awareness amongst cyclists on this issue through providing advice and information to consumers. They criticize the lack of cyclists risk awareness and feel that this explains the low rate of lights used, and see the possibility for better enforcement measures by the police. More police checks or educational measures could lead to a greater awareness of cyclists and therefore to a higher awareness of risk. The Swiss legislator is advised to make the dynamo as an "inexhaustible source of energy" compulsory again to power the lighting system. Germany is held up as an example. Mountain and racing bikes could be exempt from this requirement because in sport-oriented bicycle models only battery lights would be justified³⁹.

Comparison between similar countries on the influence of lighting regulations – Austria, France, Germany, The Netherlands and Switzerland

These European countries have similar numbers of bicycle use with defective, or with no light use as well as a similar proportion of cycling accidents in twilight or darkness of about 20% (though slightly higher in Austria of 26%). They also have similar increased risk and severity of accidents during night time cycling (though no exposure figures for France).

Their differences include the use of the bicycle in everyday use (for example Germans travel about 300km per year, the Dutch travel about 900 km per year, we can assume the French would be considerably less). There are also differences in lighting requirements

- Germany – Dynamos are required by law, they must be attached, the battery light alone is not permitted (except for race bikes), no obligation to sell bicycles equipped with lights

³⁷ Walter E, Cavegn M, R Allenbach Scaramuzza G. bicycle traffic - Accidents Risk Factors and Prevention. Bern: bfu - Swiss Council for Accident Prevention, 2005

³⁸ Scherer C, Ewert E. functionality and use of bike lights in Switzerland 1995/1996. Bern: bfu - Swiss Council for Accident Prevention, 1996

³⁹ Walter E, Achermann striker Y Scaramuzza G, Niemann S, M. Cavegn bicycle traffic. bfu safety Dossier No 08 Bern: BFU - Swiss Council for Accident Prevention, the 2012



- Austria – Battery lights are allowed and they can be detachable, there is a legal obligation to sell bicycles equipped with lights
- Switzerland - Battery lights are allowed and they can be detachable, must be seen from 100m, there is an obligation to sell bikes equipped with lights
- Netherlands – Battery lights are allowed, detachable or fixed to the body, there is no obligation to sell them with the bike
- France – Battery lights are allowed, detached only, there is a duty to sell lights with bikes though this is rarely maintained.

So even though there seems to be a similar rate of bicycle accidents in the dark and with the use of bicycle lights, these countries have very varied technical regulations and legislation. A tentative conclusion from this could be that technical regulations do not have a large effect on the use of lights or on accident figures.

To conclude on accident statistics

- Many cyclists do not have functioning lights during times of darkness; ranging from 72% - 35%
- At times of darkness there seems to be a large relative number of accidents. This cannot be concretely stated as there is a real lack of exposure figures. It is also difficult to ascertain whether this is due to lighting conditions or other factors (particularly alcohol use at night)
- There also seem to be a larger proportion of accidents occurring in extra-urban areas
- There also seems to be a greater severity of injuries during times of darkness and in extra urban areas
- EU data giving Daily/monthly/lighting conditions and numbers of accidents were inconclusive due to the lack of exposure figures and inability to test for confounding factors such as rush hour congestion or alcohol consumption etc.
- A Dutch study that does include exposure figures showed that though absolute figures were highest during the day there were *relatively* more accidents during the night. Though confounding factors could still be at work.
- It is estimated that about 6-7% of night-time accidents and 1-4% of all cycling accidents were caused by technical lighting deficiencies, or lack of lights
- A comparison of countries with similar night time accident figures, defective lighting numbers and increased risk or severity of accidents at night revealed that they all had vastly different traffic regulations and standards with regards to lighting. Concluding that different standards or regulations do not have much influence on safety.

State of the art - review of the lighting systems available



This section describes the main products used for bicycle lights. The focus is on the headlights because amongst these are found the largest quality differences. Also the headlight seems to be a little more important than the rear light for being seen⁴⁰.

Front lights

The largest differences are found in the range of headlights. The main reason is that a headlight fulfils two functions; visibility by other traffic and providing illumination of the road for the cyclist. The importance of the last function depends on the circumstances, cycling speed and user (for example how good the vision is of the cyclist).

In order to provide some measure to compare the various lights the German StVZO requirement is used as it is the main legal standard used. It gives minimum requirements as to how much light the lamp must emit on the road in different directions and maximum requirements how much light the lamp must emit to avoid dazzling of oncoming traffic. The StVZO requires a minimum of 10 Lux, however this give no guarantee that the consumer buys a good light. A light that just complies in many circumstances offers insufficient light for a clear vision on the road. With the German standard DIN 33958 there are two quality levels, 10 lux like StVZO and 20 lux. The Dutch industry has a standard with three levels - 10 lux, 7 lux and 4 lux⁴¹ - which unfortunately gives the misleading impression that 10 lux is sufficient in all circumstances.⁴²

The StVZO and DIN 33958 give no requirements about the visibility of the lights. The Dutch new standard includes them in a very low level. They both have the same requirement on dazzling, max 2 lux in straight forward direction.

LED Headlights with cut-off technology being more than sufficient to meet the StVZO requirements.

There is a wide range of high quality LED headlamps that comply with the StVZO standard, but have a much higher light output than the minimum requirements of this standard. The head lights are characterized by a lot of light combined with a broad uniform light beam and a clear cut-off of the beam so that oncoming drivers are not dazzled. They give enough light to see the road under almost all circumstances. They are available as dynamo and battery powered.

Examples of such headlamps are:

⁴⁰ See the accident scenario's in the TNO report about visibility of bicycle light from 2008 http://www.fietsberaad.nl/library/repository/bestanden/Eindrapport_Fietsverlichting.pdf

⁴¹ <http://www.raivereniging.nl/activiteiten/keurmerken/keurmerk%20fietsverlichting/technische%20eisen.aspx>

⁴² This presentation of Dutch bicycle light manufacturer gives good examples of different headlights.

<http://www.fietsberaad.nl/index.cfm?lang=nl&repository=Presentatie+Peter+van+Vlijmen+Keurmerk+Fietsverlichting>



- Busch & Muller IQ⁴³
- Philips Saferide⁴⁴
- Axa Nano⁴⁵
- Trelock LS-950 and LS 875⁴⁶

The headlights are used by commuters who like to cycle throughout the year. In Germany they are also fitted by a lot of manufacturers on new bikes, though this is rare in the Netherlands. These are the best available headlights. The only problem is the adjustment. If the light beam is adjusted too high this leads to dazzling of oncoming traffic, if the light beam is too low it leads to a bright, small beam and no vision outside the beam.



Figure4: Example of the Philips Saferide

LED Headlights with cut-off technology that just meet the StVZO standard

⁴³ <http://www.bumm.de/produkte/dynamo-scheinwerfer/lumotec-iq-fly.html>

⁴⁴ http://download.p4c.philips.com/files/b/bf60l60balx1/bf60l60balx1_pss_aen.pdf

⁴⁵ <http://www.axacompany.com/EE/nl/axasite/products/lichten/>

⁴⁶ http://www.trelock.de/web/en/produkte/fahrrad-beleuchtung/batterie-frontscheinwerfer/8002095_LS_950_ION.php



There is a wide range of LED headlamps that just comply with the StVZO standard. They are characterized by moderate to reasonable amount of light. Quality of the light beam varies greatly. In many circumstances they give insufficient light output to provide good vision on the road, especially when the beam design is small (often used to merely provide the impression of a powerful light). Examples of such headlamps are:

- Trelock LS450⁴⁷
- Busch & Muller Lumotec Lyt⁴⁸
- Axa Sprint⁴⁹
- Spanninga Luceo⁵⁰

Besides the amount of light and the design of the light beam, the only problem again is the adjustment. Light beam adjusted too high means dazzling of oncoming traffic. Light beam too low means a bright, small beam and no vision outside this beam.



⁴⁷ http://www.trelock.de/web/en/produkte/fahrrad-beleuchtung/sportline/8002281_LS_450.php

⁴⁸ <http://www.bumm.de/produkte/dynamo-scheinwerfer/lumotec-lyt.html>

⁴⁹ http://www.velofred.com/product_info.php?products_id=806

⁵⁰ http://www.spanninga.nl/xhtml/product_derears.php?cid=9&pid=140&cc=1



Figure5: Light beam of the Spanninga Luceo

Headlights with classic halogen bulb and cut-off technology that just meet the StVZO standard

Lights with bulbs that just comply with the StVZO standard are still used. They are characterized by moderate light output and the quality of the light beam varies greatly. In many circumstances they give insufficient light output to have a good, clear vision of the road, again especially when the beam design is small. Examples of such headlamps are:

- Busch & Muller Lumotec Oval⁵¹
- Axa Horizon⁵²
- Spanninga Micro FF⁵³

In the Netherlands the headlights are still sold on cheap bicycles and children's bicycles. Besides the amount of light and the design of the light beam, there are problems with the life time of the bulb and low light output at low speed (a dynamo is designed to have full output at 15 km/h. By lower speed the energy output of the dynamo reduces linearly⁵⁴).

⁵¹ <http://www.bumm.de/produkte/dynamo-scheinwerfer/lumotec-oval.html>

Before the coming of the LED one of the best headlights, today very much outdated

⁵² <http://www.bicycleworkshop.co.uk/products.php?plid=m2b0s133p49>

⁵³ http://www.spanninga.nl/xhtml/product_derears.php?l=en&cid=9&pid=62&cc=1

⁵⁴ the reduction of light output of a LED remains linear but the light output of a classic bulb reduce much more



Figure6: Light beam of the B&M Lumotec Oval. It is hard to believe that this light was considered to be a very good headlight 10 years ago.

Powerful LED lights with round beam

There is a wide range of powerful LED headlights with a round, bright beam. They are similar to the high beam of cars. They are almost exclusively battery driven (Supernova is the exception)

Examples of such headlamps are:

- Supernova E3 Triple⁵⁵
- CateEye Nano Shot+ HL-EL625RC⁵⁶

The headlights are mainly used by mountain bikers and road cyclists. They are only sold separately. They have two advantages above the lights with cut-off beam. Firstly the design is much cheaper and secondly the round beam gives a better vision in a

⁵⁵ http://supernova-lights.com/en/products/e3_triple.html

⁵⁶ <http://www.cateye.com/en/products/derear/HL-EL625RC/>



dark mountain biking environment such as forests etc. since the trees and other objects are also enlightened.

However a major problem is that even when the lamp is properly adjusted, the round beam always dazzles oncoming traffic, just like the high beam of a car.

Weak LED headlights with narrow round beam technology

There is a wide range of weak LED headlights with a small little beam. Main characteristics are that they have a low light output (and therefore a long battery lifetime) combined with a narrow beam. The narrow beam suggests that they provide a strong powerful output. However in practice, the light bundle is too small and seeing outside the beam is hard. They are mainly used with disposable batteries.

Examples of such headlamps are:

- CatEye HL-EL340 Econom⁵⁷
- BBB BLS-30⁵⁸

The headlights are used by many cyclists who do not want to use dynamo lighting but want to have the feeling they have a good light with long battery life time. They are mainly sold separately.

Again a major problem is that if the lamp is not properly adjusted, the round beam dazzles oncoming traffic, and when the batteries low the light is too weak for visibility.

Weak LED headlights with wide diffuse beam technology

There are also weak LED lights with a wide diffuse beam on the market. Main characteristic is that they have a low light output (and therefore a long battery life) combined with a wide beam. They are mainly used to be make the cyclist visible, however the wide beam is surprisingly good for seeing the road at low cycling speed and much better than a narrow beam from a light with the same light output. They are mainly used with disposable batteries. Examples of these lights are

- CatEye HL-EL135⁵⁹
- Axa comet IV⁶⁰

These headlights are often used by cyclists for visibility, and who want to be able to see sometimes on unlit roads, they are mainly sold separately. It is unclear whether such lamps dazzle oncoming traffic or not.

⁵⁷ <http://www.cateye.com/en/products/derear/HL-EL340/>

⁵⁸ http://www.profirad.de/beleuchtung-alloyhead-bls30-p-9880.html?products_id=9880&reviews_id=666&language=en&osCsid=

⁵⁹ <http://www.cateye.com/en/products/derear/HL-EL135/>

⁶⁰ <http://www.ligfiets.net/product/accessory/428/axa-basta-comet-iv.html>



Very weak LED headlights with no beam.

There is a wide range of very weak LED headlamps which are intended solely for visibility to other traffic.

Examples of such headlamps are:

- BBB BLS 53⁶¹
- Knog Frog Strobe⁶²

These lights are used by cyclists who want to be visible but do not want to spend a great deal on expensive lights. The main reason for use is being to avoid a traffic ticket!⁶³ They are only sold separately.

With fully charged batteries, the light output is good enough for visibility for some products, according to the TNO report 2008⁶⁴, (often in fact as good as the old, classic headlight with bulb). A major problem is that batteries are not replaced quickly enough and that the lights are often mounted incorrectly by the cyclist (red and white the wrong way around for example). Also according to the TNO report⁶⁵ there is a big difference in visibility quality.

⁶¹ <http://bbbcycling.com/accessories/lights/BLS-53/>

⁶² <http://www.knog.com.au/gear-lights/frog-strobe.phps>

⁶³ In the Netherlands

⁶⁴ http://www.fietsberaad.nl/library/repository/bestanden/Eindrapport_Fietsverlichting.pdf

⁶⁵ *ibid*

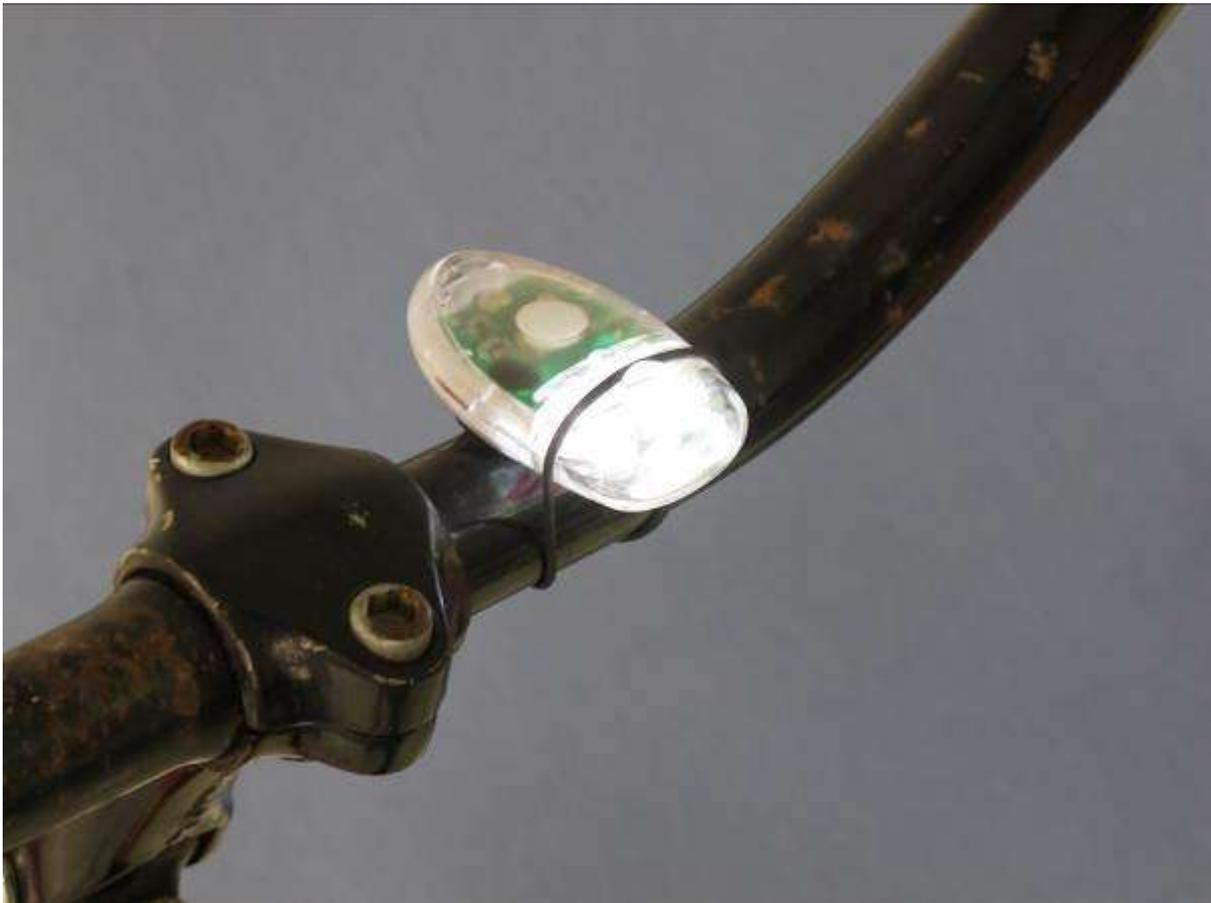


Figure7: Headlight Hema with button batteries



Figure8: Good 'to be seen light' with 2 AAA batteries.

Rear lights

The TNO 2008⁶⁶ study shows that almost all rear lights works good enough, even the cheap ones. In practise cyclist have the following problems:

- Broken lights
- Batteries too low
- Light not directed straight backwards
- Light covered with part of the bicycle or cyclist
- Broken wires (dynamo powered rear light).

Best position of the rear light is on the end of the mudguard or on the end of the luggage carrier. Most click-on rear lights are designed to be mounted on the seat post. A light on the seat post is easily covered with a coat. A light mounted by the rear axle is positioned quite low and covered by the bicycle in some directions. There are also helmets with build in red lights.

⁶⁶ http://www.fietsberaad.nl/library/repository/bestanden/Eindrapport_Fietsverlichting.pdf



Power sources

The following power sources are used for bicycle light

- Hub dynamo
- Bottle dynamo
- rechargeable batteries
- disposable batteries
- button cell batteries
- Battery electric bicycle
- magnet Alternator

The hub dynamo is the most reliable source of energy for the bike. Although there are large price differences between the models, they are all very reliable as a source of energy. There are differences in the weight, efficiency of the hub, resistance when the lights are switched off and quality of the bearings.

Hub dynamos in Germany are fitted on almost all new bicycles and in the Netherlands are fitted on new city bikes with the exception of the cheap bicycles. Hub dynamos cannot be used on pedelecs with front motor.

The classic bottle dynamo delivers as much energy as the hub dynamo but is inferior in all other respects. It is easily damaged, slips in rain or snow, it makes a lot of noise and has a lower efficiency. Bottle dynamos are only mounted on cheap city bikes and are also still much to be found on old bikes. However replacement of a bottle dynamo by a hub dynamo means a new front wheel.

Dynamos are designed to deliver constant energy above a speed of 15 km/h for the classic light bulbs (6V/0,4A (front) and 6V/0,1A (rear)). Dynamos with a different output and designed specifically for the properties of LED are very rare.⁶⁷

At speed less than 15 km/h the energy output drops linearly. For classic light bulb this becomes a problem because the light output drops dramatically. For LED this is less of a problem. A dynamo only delivers energy when the bike is in motion although most dynamo lights have a capacitor to power the light when standing still. It works well with LEDs but less well with classic light bulbs.

Reelight (See Figure11) use 2 magnets in the wheel to power a small LED light, this is in fact a dynamo with a very low energy output. For technical reasons, the lights must be installed quite low near the hub. This may not be the best place for them to be seen.

⁶⁷ possibly as a result of the German regulations



Figure9: Hub dynamo with electric parts inside the hub.



Figure10: Classic bottle dynamo



Figure11: Reelight with a simple dynamo with very low output.

Batteries

The powerful LED lamps for batteries are used mostly with rechargeable batteries. Most lights use rechargeable NiMh AA-batteries. There is currently a trend in the use of internal lithium ion batteries⁶⁸.

The biggest drawback of rechargeable batteries is the power diminution and knowing when the batteries need to be charged. Battery lamps that conform to the StVZO must have an indicator, but they are often not very accurate. Other drawbacks are the self-discharge of the battery, so they cannot be used on light that are rarely use.

Disposable batteries are used on LED-lights with low energy consumption and LED-lights that are rarely used, mostly 2 AA or 2 AAA batteries. Sometimes used in the Netherland are the button batteries for very small lights.

The batteries of pedelecs are also used to power lights. The advantage is that there is no need of an extra source for the light. Though seems risky as this relies on the

⁶⁸ similar to those used in GSM and cameras



battery of the pedelec never being empty. But an empty battery for the engine can still deliver enough energy to power the lights for more than a hour. And it is hard to expect that the user will cycle without electric assistance in dark for too long. In Germany this is illegal so Pedelecs in Germany still have an extra dynamo, but there may be changes to this in 2013.

Light sources used for bicycles lights

15 year ago only the ordinary bulb and halogen bulb with filament were used for bicycle lights. Today the bulb has been almost completely replaced by LED's.

This light bulb has a few major disadvantages compare to the LED

- Short lifetime (100 hours vs. 100,000 hours)
- Low efficiency (a LED gives 5 to 8 times more light with the same amount of energy)
- A light bulb can only burn with a fixed voltage. Voltage too high means a very short lifetime, too low means no light at all. A LED can very easily provide light with different output and still gives quite a lot light with low energy input⁶⁹

LEDs some minor disadvantages

A LED cannot be connected directly to a dynamo or battery. A LED always needs some (simple) electronics to power it. And the heat produced by the LED⁷⁰ warms up the casing. With a bulb the heat produced is thermal radiation that is thrown into the air.

With an ordinary 6V/2,4Watt bulb it is impossible to meet the German StVZO requirements; with halogen lights it is just possible. It is for this reason that the classic bulb is no longer used in Germany.

Main problems with bicycle light

On bicycles the following problems occur:

- No light at all
- Broken light
- Batteries too low
- Wrong adjustment
- Use of flash light (in some countries illegal)
- Covering of the light in some direction (by bike equipment or clothing)
- Bad design of the beam
- Light output too low for illuminating the road (but depends very much on the circumstances)
- Light output too low for visibility
- Wrong colour of the light

⁶⁹ In other words it is even more efficient with lower currents

⁷⁰ still most electric energy is converted into heat



- Wrong number of lights
- Broken wires
- Broken dynamo (reasonable common with bottle dynamos, rare with hub dynamos)
- Some light from the lamp shines directly into the eyes. A disadvantage of most powerful dynamo lights with integrated reflection. A problem on dark roads because the night vision is worse as a result of the direct light.)

Flash lights

Most cheap LED-lights and even some LED light with high output have a flashing function.

The main 2 reasons cyclist use flashlights are:

- Cyclists think they are more able to be seen with flashing lights
- It saves runtime of batteries

For manufacturers it gives no extra cost to add a flash function and it makes the light more attractive in the shop.

TNO 2008⁷¹ has tested the conspicuousness of flashing light compare with the same steady light. In the graphic is the conspicuousness given in different circumstances.

⁷¹ http://www.fietsberaad.nl/library/repository/bestanden/Eindrapport_Fietsverlichting.pdf

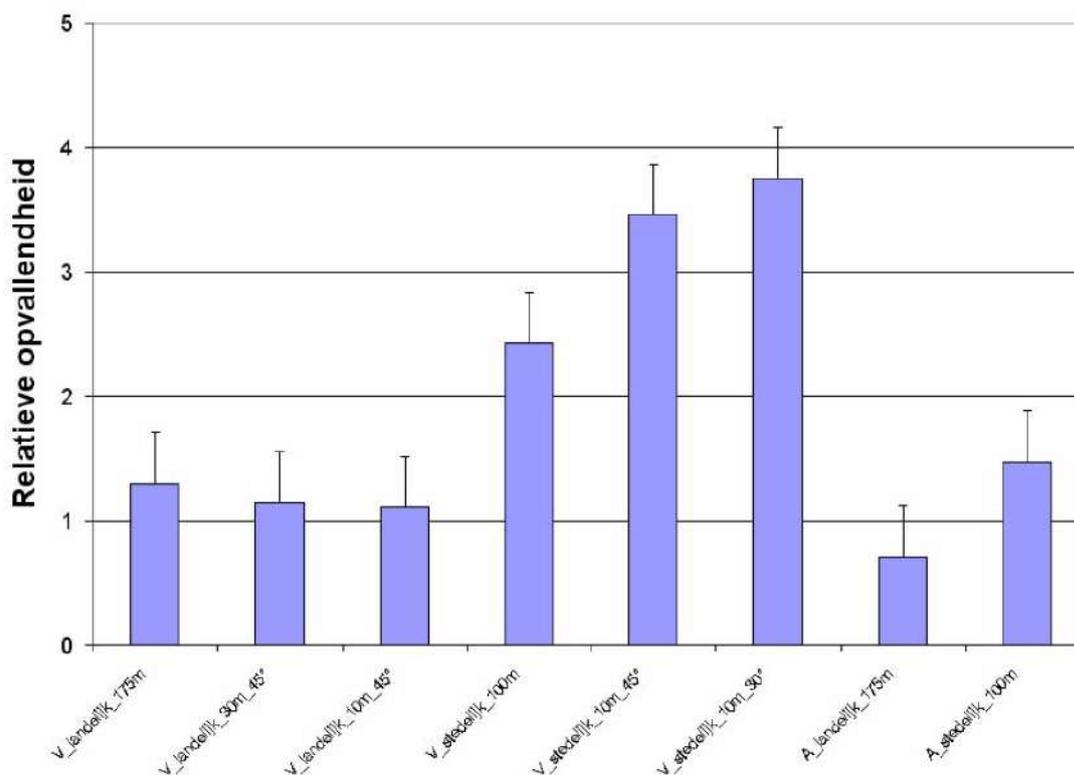


Figure11: ratio of conspicuousness angle indicator relative to constant light at different scenarios, averaged over all bike lights (7 for lamps, 4 rear lights). V = average of the tested front light, A = average tested rear light. Relatieve opvallendheid = Relative conspicuity (no flashing = 1). Landelijk = country, stedelijk = urban.

In summary it can be concluded that flashing bicycle lights are not necessary for a good conspicuity. Maybe in the urban area flashing lights increase the conspicuity, for crossing traffic where the cyclist from the right or where the motorist turns right⁷². This increase could be especially important for those with low quality lights with poor conspicuity. From the rear, the flashing lights do not bring any additional benefits and in fact in rural areas even leads to a decrease in conspicuity.

Flashing also has the following general disadvantages:

- it may confuse others, for example confusion with the lights from an emergency vehicle
- it may irritate others
- It makes other traffic participants less visible
- It makes it hard to judge the distance and path followed by the cyclist

So, there seems little use for flashing and certainly should not be promoted.

⁷² Left in Cyprus, Ireland, Malta and the United Kingdom



Retroreflectors

On bicycle the following reflectors are used:

- Front white,
- Rear red
- Pedal amber/yellow
- Wheel, white or amber/yellow.

Working

A good reflector is a retroreflector⁷³. That means the light is reflected⁷⁴ back to its source. A retroreflector only works if it is illuminated by a bright light. In practice a retroreflector works only in the light of a car or motorcycle.

The visibility of the reflector decreases sharply with the distance from the light source. The TNO report 2008⁷⁵ shows that at a distance of 15 metres a rear light and a rear reflector have the same visibility. At 100m the reflector is just visible at 100m while the rear light has the same visibility at 700m (see Figure 12 below). The visibility of a reflector is especially bad in rain and fog because of the absorbing wet atmosphere conditions that the light must travel through.

⁷³ <http://en.wikipedia.org/wiki/Retroreflector>

⁷⁴ http://en.wikipedia.org/wiki/Reflection_%28physics%29

⁷⁵ http://www.fietsberaad.nl/library/repository/bestanden/Eindrapport_Fietsverlichting.pdf

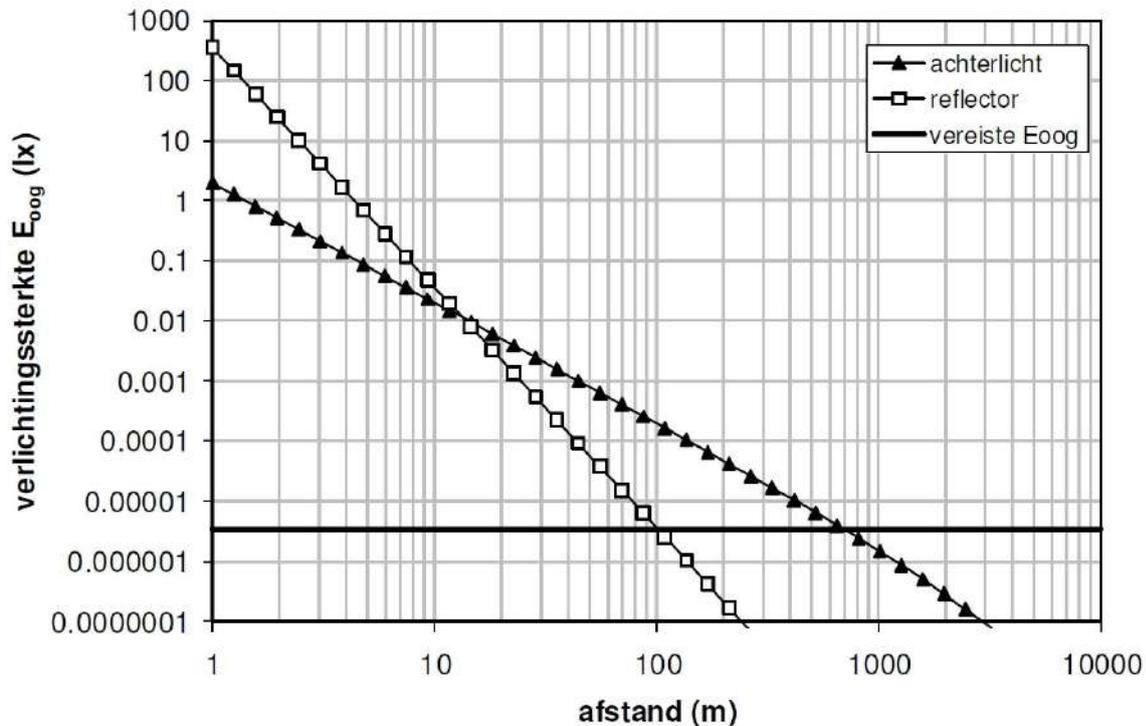


Figure 12: Illumination on the eye of the observer, with the light of a rear light, and a retro-reflector as a function of the distance. The reflector reflects the light beam of a car. The black horizontal line is the light needed for 'just visible'. Achterlicht = rear light. Afstand = distance. Verlichtingssterkte oog = illumination on the eye.

TNO⁷⁶ has not investigated the visibility of Retroreflectors. They have only looked at the light output and compared this with a rear light.

Front and rear reflectors

Most dynamo headlights have a small integrated front reflector while most battery lights do not have a front reflector. Cheap battery lights like the Smart have a casing that looks like a reflector but is in fact not a real retroreflector.

⁷⁶ Ibid.



Figure13: Bicycle with a front retroreflector. The reflector is hard to see.



Figure14: Bicycle with front light. Much better than the reflector



Figure15: Rear view with rear and pedal reflector. In practice the bicycle is more easily recognised by the movement of the pedal reflectors. The casing of the red rear light on the saddle is not visible.



Figure 16: Cheap rear light and reflectors. The reflectors are still visible at close distance.

Wheel reflector

Most city and trekking bike tires for the European market have an integrated small white 3M-reflection tape, though not on racing and mountain bikes, most often for aesthetic reasons, but also for technical reasons. The thin sidewall on these tires is easily destroyed by the stiff tape. They are also not put on many small tires (for children bicycles for example).

For retrofitting 3M sells spoke reflectors.

On small wheels and children's bikes it is quite common to use 2 amber/yellow reflectors in the wheel.

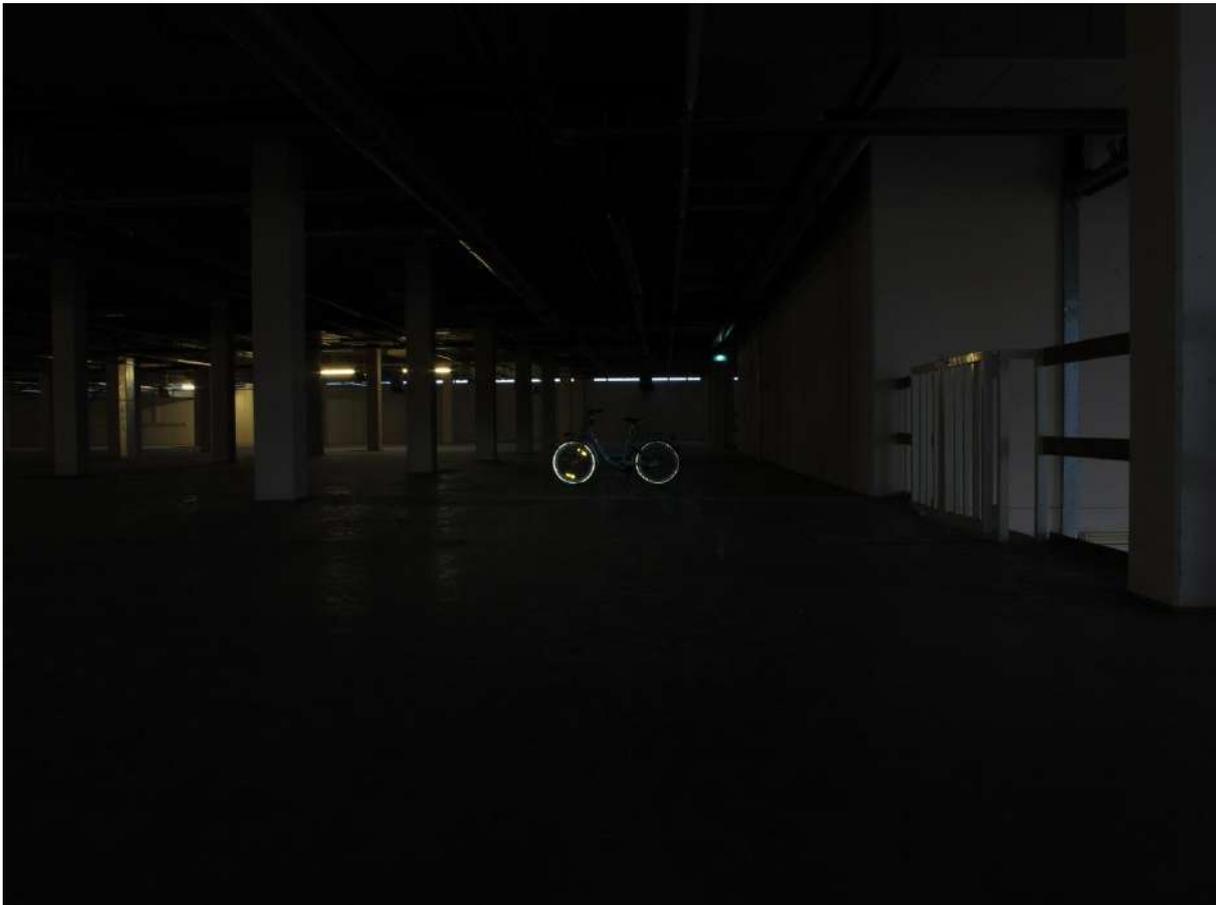


Figure 17: Child bicycle with tire reflection and reflection in the wheel.



Figure18: The yellow spoke reflection seems to be more visible than the wheel reflector.

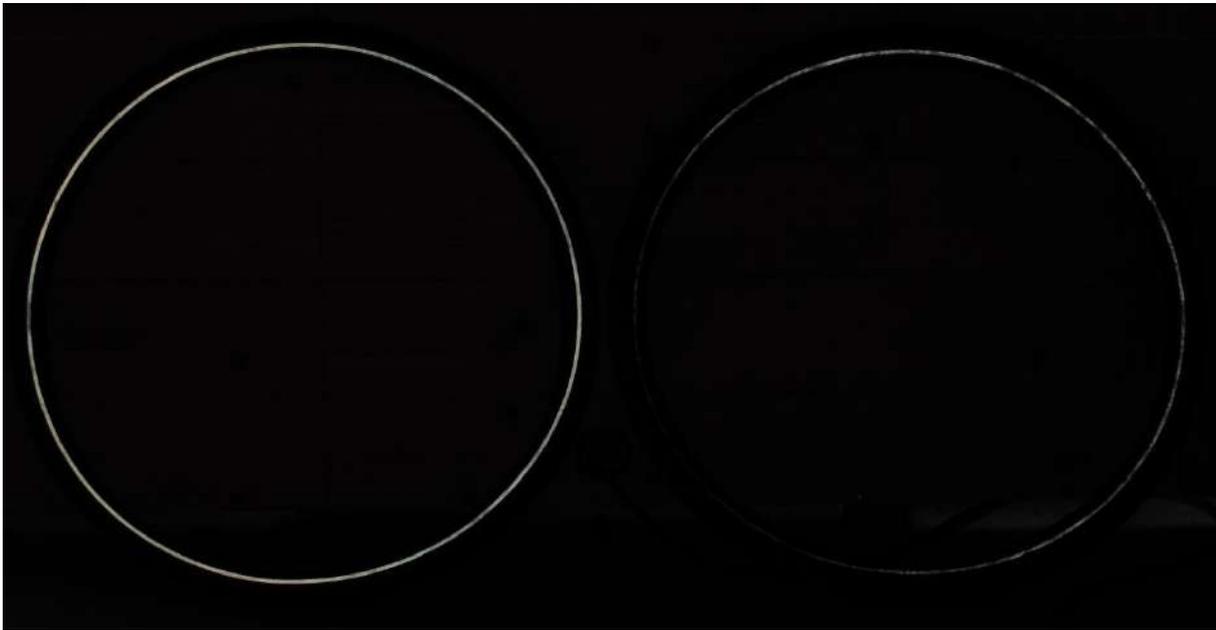


Figure 19: A new and a used tire. The reflection becomes dirty by dirt from the street and dirt from the rubber of the rim brake.

Pedal reflector

Most pedals for city and trekking bicycles have 4 amber yellow retroreflectors. The movement of the pedals gives the motorist some extra information and seems to work reasonably well in identifying the cyclist. Clipless pedals and pedals used for BMX have no reflectors.

Clothing with reflection

Some cyclist wear reflective clothing or vests such as hi-visibility jackets similar to those used when the car is stranded on the hard shoulder or side of the street. Again these seem to work pretty well.

In Common

Most bicycles for daily use are fitted with much of this reflection. Sports bikes though are fitted with hardly any reflection. Semi-sport bikes like trekking bikes lack some reflective materials but not as much as the sports bikes (for example if the cyclist use clipless pedals).

Retroreflectors are very cheap. Even those that comply with the German standard⁷⁷

⁷⁷ See for example <http://www.roseversand.com/article/b--m-front-reflector/aid:50519>.



Currently there is a small trend to complement the passive reflection of the wheel and pedals by using little LEDs (like the CatEye in the road with LEDs that replace the reflection strips), though in many countries this is illegal.

The reflection is often integrated in the design of the front and rear light. However though the red and white casing of cheap battery lights look like a retroreflector it is not.

The following problems occur with reflection:

- Not fitted on the bicycle (especially sport bicycles)
- Are sometimes broken
- Can get dirty. Especially the reflection strip. Tires last much shorter than the lifetime of the strip. When rim brakes are used, the reflection strip seems to become useless after time because of dirt covering it from the brakes.
- Covered by parts of the bicycle (bags, clothing, cargo bike, recumbent)
- Disappears when the rear light or headlight is replaced by a cheap battery light
- Wrong colour, for example white for rear or red for front.
- Wrong place or numbers of reflectors.

Conclusions

- A problem with the best lights was to not dazzle oncoming traffic. Many have much more than necessary.
- Those that just complied often gave limited vision of the road. They also tended to have smaller beams which concentrated output to *suggest* that they gave better illumination than was in fact the case.
- Weak beam 'to be seen' lights, these seem to be the bare minimum. They are a cheaper option and used to conform to regulations.
- Even many of the cheap rear lights were effective and sufficient
- With regards to power sources the hub dynamo was the most reliable, although there could be issues with varying light output at different speeds
- LED lamps were becoming almost universal now and have long replaced the halogen as the state of the art with higher lifetime, higher efficiency, greater lighting etc.
- Flashing lights were seen as having many issues such as confusing other vehicles (as emergency vehicles), being harder to judge distances. From the rear they seem to add no additional benefit and in rural areas seem to lead even to a decrease in conspicuity
- Reflectors only really work at short distance and in the presence of a strong incoming light
- If the cycle is equipped with a good light reflectors barely add to the visibility, they are certainly not a replacement for lighting
- But they could be seen to be a cheap and reliable emergency option



Law - National and international regulations (requirements) on lighting (light intensity) and reflectors of bicycles

Austria

Lights

White or yellow headlight which is attached to the bicycle and illuminates the road in front of the bicycle; must have light output of 100 candela; flashing lights are not allowed.

Red rear light, at least 1 cd, attached to the bicycle, which may blink.

Reflector – not mandatory for racing bikes

White reflector at front, min. area 20 cm²

Red reflector at back, min. area 20 cm²

On wheels: 2 yellow reflectors per wheel on spokes, min area 20 cm²:
alternative can also be reflective strips in sidewall of tyres

2 yellow reflectors per pedal

Belgium

Lights

Bicycle Lights are only obligatory if the visibility is less than 200metres. They may be put on clothes or helmets with a white in front and a red at the rear. Between sunset and sunrise and in any circumstance where it's not possible to see clearly at a distance of about 200 meters, cyclists have to use front and back a steady or flashing light. At the front, the light must be white or yellow. Back, red, flashing light also allowed here.

The rear light has to be visible at night by fine weather, at a minimum distance of 100 meters.

Reflectors

The bicycle has to be equipped with a permanent white reflector in front and a red reflector to the rear of the bicycle.

The red reflector has to be distinct from the red light.

The pedals of the bicycle have to be equipped permanently with reflectors yellow or orange.

The bicycle has to be equipped with lateral reflectors or signals



Bosnia and Herzegovina

Light

From first dusk until complete dawn (during night), as well as during the day when there is reduced visibility...lights for visibility must be on all vehicles including the bicycle with one white light on the front and one red light on the rear of the bicycle

Reflectors

One red reflector on the rear of the bicycle, and one yellow or orange reflector on each of the pedals.

Bulgaria

The Law for the traffic concerns all vehicles including the bicycle and the need for proper lights. Reflectors are obligatory according to the traffic law.

Czech Republic

Lights

Bicycles in reduced visibility must be fitted with

- a) A light shining forward white light; the headlamp must be aligned and adjusted continuously so that the reference axis light intersects the ground plane at a distance of 20 m away from the lamp, and that this adjustment cannot change spontaneously or unintentional interference with the driver
- b) A rear red lamp, which may be combined with a rear red reflector pursuant to paragraph 1. e) rear red lamp may be replaced with a flashing light
- c) a source of electricity, if it is a source with a supply of energy, must have a capacity intensity of the lights referred to in points a) and b) for at least 1.5 hours without interruption.

Reflector

rear red reflector can be combined with a red rear lamp or replaced with reflective materials with similar characteristics; reflecting surface shall be not less than 2000 mm², with an inscribed quadrilateral must have at least one side of 40 mm. The reflector must be firmly placed in the longitudinal median plane of the bike or on the left side closest to it in height from 250 to 900 mm above the ground plane; the illuminating surface must be perpendicular to the plane of the road within +/-15 ° and perpendicular to the longitudinal median plane of the bike +/-5 °, reflective materials in clothing or footwear can replace rear reflector
front white reflector, the reflector can be replaced with reflective materials with similar characteristics



Denmark

Lights

Between sunset and dusk it is compulsory to use lights as well as in weather with restricted visibility, for example fog and heavy snow; white front and red at the back which can be seen from a distance of 300m without being blinding. The lights must be placed on the bike and not on the cyclist. Bike lights in back pockets or on the leg must not be used alone but they can be used as a supplement to the ones mounted on the bike.

Front lights that are white can flash at least 200 times a minute.

Yellow front lights must not blink.

Back lights must be red and a back light may flash but it must be at least 200 times a minute.

Reflectors

A white reflector in the front and a red reflector at the back and a yellow on each wheel seen from the side, or with white reflective tyre or rim reflectors and 2 yellow (normally on pedals) seen from the back.

Finland

Lights

During darkness or twilight or when visibility is restricted due to weather conditions bicyclist shall have a white or yellow light in front. A red light in rear is allowed but not mandatory. Lights must not dazzle other drivers. There are no restrictions where lights should be mounted on a bicycle laterally. Vertically the minimum height of the lights measured from the surface of the road is 0,30 m and the maximum 1,30 m.

The legislation is interpreted so that light shall be steady and blinking lights are not allowed.

The police may fine bicyclists not using proper lights but this happens only rarely. The police usually accept even blinking lights because "they are better than nothing".

Reflectors

A bicycle shall have a white reflector in front, red one in rear. It shall have brownish yellow reflectors visible to the sides in front and rear, and brownish yellow reflectors on both pedals. There are some exceptions to these requirements including bikes under 10kg. The minimum height of the front and rear reflectors measured from the surface of the road is 0,30 m and the maximum 1,20 m.

The maximum amount of reflectors on a bicycle is not restricted.

France



Lights

Lights are mandatory during the night or bad weather with white or yellow light on front and a red light at the rear. Flashing front or rear light is officially insufficient. You can have it as something added, but not as the main mandatory light. Without one of these elements you can have a fine of first class, the lowest fine possible 11 euros.

Reflectors

White reflector on front

Red reflector at the rear

Orange reflectors on wheels and on pedals

If a trailer is wider than 1m30 you need extra reflectors.

Germany

Lights

StVZO§67 Bicycles have to be equipped with front and rear dynamo lights. The lights have to be powered by a 6V/3Watt dynamo. Only race bikes are allowed to be used with battery light. The front light beam must be at least as inclined as its centre at 5 m forward of the headlamp is only half as high as it emerges from the headlights. The rear red light must have a the lowest point of the illuminating surface not less than 250 mm above the ground

Reflectors

1 white at the front

2 yellow or white at the spokes (or a reflecting band at the tyres)

2 yellow at the pedals

2 red at the rear

Iceland

Lights

A bike used in darkness or reduced visibility should have a white front light and a red rear light.

Icelandic regulation no. 57/1994, 4. Paragraph.

http://us.is/Apps/WebObjects/US.woa/swdocument/997/Regluger%C3%B0+um+ger%C3%B0+og+b%C3%BAna%C3%B0+rei%C3%B0hj%C3%B3la%2C+n.r.+57_1994.pdf

Reflector

A bike should carry a white front reflector, a red rear reflector, yellow/white reflectors in the spokes and yellow/white reflectors on the pedals.

Ireland



Lights

A front lamp means a lamp that is fitted to a non-mechanically propelled vehicle showing to the front a white or yellow light that is visible for a reasonable distance.

A rear light that when fitted to the rear of the bicycle and when it is lit, a red light visible for 152 meters (500 feet) should be visible.

Lamps do not need to be lit when stopped in traffic or when a person wheels the bicycle on foot as near as is possible to the left-hand edge of the road.

Under SI 487 of 2009, since 14 December 2009 it is legal to use flashing front and rear lamps.

Exceptions are made when the bicycle is stationary in traffic.

Reflectors

All bicycles used on public roads in Ireland must at all times display a rear reflector. A rear reflector means a red reflector that can be plainly seen for a distance of 99 meters (325 feet) to the rear when the headlights of a vehicle shine directly on it. The only exception to this rule is on a child's bicycle where that bicycle is used during the daytime.

Italy

Lights

In the Highway Code lights are mandatory for every kind of bicycle with a white light in front and red light in the rear.

However this rule is not really respected and for racing bicycle and MTB normally the bicycle shop deliver red and white lights (bulbs) in a box separate from the bicycle.

Reflectors

One reflector on front and one at rear

Latvia

Lights

At night or in case of limited visibility front of bike there should be switched on white light, but in the back of bike- red light.

Reflectors

Bike should be equipped from both sides (in wheels) with 2 orange (yellow) light reflectors,



Lithuania

Lights

White light on the bike during dark time in front, red - in the back

Reflectors

Red reflector in the back of the bike, orange reflectors from both sides;

Netherlands

Lights

White or yellow at the front and red at the back required at night (between sunset and sunrise) and bad weather conditions (not specified). The front light should be connected to the bicycle or chest of the cyclist and should be visible for oncoming traffic. the rear light should be connected to the bicycle or back of the cyclist and should be visible to traffic approaching from behind (so helmet lights are not allowed). The back light must be attached to the bicycle at a distance of 26 to 120cm above the road surface. No extra lights are allowed (so a bicycle with 2 operated front light with dynamo is illegal. Flashing lights are not allowed, and lights must not dazzle oncoming traffic

Reflectors

Bicycle must be fitted with red reflector visible from behind and 4 orange reflectors on the pedals. White or yellow wheel reflectors. Front reflectors are not mandatory. No extra reflectors are allowed. There is an approval mark on the reflectors (but there is no approval certificate).

Poland

Lights

Bicycle must be equipped with a white or yellow light in the front and with a red light in the rear. All lights must be visible at night from at least 150 meters. All lights must be fitted to the bike 35 cm above street level and no higher than 95 cm. Rear light may be flashing.

Reflectors

Bicycle must be fitted with red reflector visible from behind and orange reflectors on the pedals. Front reflectors are not mandatory.

Romania



Lights

Bicycle must be equipped with a white or yellow light in the front with and with a red light in the rear if the rear light of the bicycle is covered by the trailer, the latter must be equipped with a red light.

Reflectors

At least one white visible fluorescent-reflector device in the front and one red at the rear.

It is forbidden for the riders of bicycles to ride during the night or when the visibility is decreased, without fulfilling the above requirements and to ride without wearing clothing with fluorescent-reflector elements, from the onset of twilight until dawn, or when the visibility is decreased.

Slovenia

Lights

The bicycle has to be equipped with white front light and rear red light

Reflectors

White in front, red in the back and side amber reflectors on both wheels.

Sweden

Lights

Bicycles must have a white/yellow light in front and a red light at the back which must be seen up to 300 metres away or of such intensity that the vehicle at night can be seen in a satisfactory manner.

Rear light on a bicycle may deliver flashing lights as long as it is at least 200 flashes / minute.

Reflectors

Bicycles must have one fixed reflector in front (white), one behind (red), and also side reflectors (orange or white)

The fine is 300 Kroner per missing light

There was a Swedish standard "Lighting equipment for bicycles" but it was withdrawn in 2010



Switzerland

Lights

Bicycles must have at least a white (in front) and a red (behind) static light. These must be seen from 100m. They may be fixed or removable. Lights must not dazzle.

Reflectors

Bicycles must have one fixed reflector in front (white) and one behind (red) with a size of at least 10cm². They must be seen by night from 100m at least. Reflective clothing may be used instead of reflectors as it is visible at 100m in the headlights of a standard car.

Also the pedals must be equipped with reflectors with a size of at least 5 cm². Special racing pedals are exempt.

United Kingdom

Light

Road Vehicle Lighting Regulations⁷⁸ states that at night between sunset and sunrise your cycle must have white front and red rear lights lit conforming to BS 6102/3. The rear light must be positioned centrally or offside, between 350mm and 1500mm from the ground, at or near the rear, aligned towards and visible from behind. Front light positioned centrally or offside, up to 1500mm from the ground, aligned towards and visible from the front. Flashing lights are permitted at a rate between 1 and 4Hz and has a luminous intensity of at least 4 candelas but it is recommended that cyclists who are riding in areas without street lighting use a steady front lamp.

Other lights are allowed to be fitted only as an addition to the main lights, these lights do not have to conform to BS Standards, but must not dazzle other road users.

If either of the lights is capable of emitting a steady light, then it must conform to BS 6102-3 and be marked accordingly, even if used in flashing.

Purely flashing lights are not required to conform to BS6102-3, but the flash rate must be between 60 and 240 equal flashes per minute (1-4 per second) and the luminous intensity must be at least 4 candela. (This should be advised by the manufacturer).

Reflectors

The bicycle must also be fitted with a red rear reflector (and amber pedal reflectors, if manufactured after 1/10/85) conforming to BS 6102/2, positioned centrally or offside, between 250mm and 900mm from the ground at or near

⁷⁸ <http://www.legislation.gov.uk/uksi/2009/3220/contents/made>



the rear, aligned towards and visible from behind. Front reflectors are not necessary if there is a light present

Lights and reflectors not conforming to the BS, but conforming to a corresponding standard of another EC country and marked accordingly, are considered to comply as long as that standard provides an equivalent level of safety. In reality this is the German standard.

Ukraine

Lights

For riding at night and in low visibility bike must be installed with lights and to have them turned on.

Reflectors

Bicycle must have white front reflectors, orange viewed from the side and red at the rear.

Vienna Convention on Road Traffic 1968

Lights

A white or selective-yellow light to the front and a red light to the rear.

Article 44 - "Cycles without an engine in international traffic shall: (c) Be equipped with a red reflecting device at the rear and with devices such that the cycle can show a white or selective-yellow light to the front and a red light to the rear"

Reflectors

Be equipped with a red reflecting device at the rear

Conclusion

- There are almost as many traffic regulations regarding lighting as there are countries.
- Regulations range from
 - the simple; white front red back (Slovenia)
 - Distance only; lights must be seen 300m away (Sweden)
 - Complex; UK, Germany, Netherlands
- Only the UK regulations refers to a particular standard



Standards currently available with regards to lighting systems for bicycles

Germany –

The only technical national standard is in Germany DIN 33958⁷⁹. However Road Regulation StVZO does not refer to the DIN standard but rather to specific "Technische Anforderungen" (TA, Technical Requirements) that are laid down in an annex to the StVZO.

The Netherlands – The Dutch regulations do not mention a standard when applying road traffic laws. There was a standard that was a part of the Vehicle regulations though it no longer applies⁸⁰. The industry in the Netherlands has, with DEKRA NL, brought out recently a new standard⁸¹ but this has no legal weight.

United Kingdom –

There are British BS standards. BS 6102/1 on pedal reflectors used to exist but is now replaced by ISO standards. However BS 6102/2 (reflectors) and BS 6102/3 (lights) still exist for products in the UK working within the Road Vehicles Lighting Regulations. Legally a bike must have lights and reflectors that conform to the standard but other non-approved lights are allowed to be sold and used as additional to the legally required lights. Because of a lack of enforcement there are not many lights sold that are fully compliant with the standard (perhaps one or two). However lights "...can also conform to an equivalent EU standard". In reality this means the German standard.

ISO standards –

Currently work being done by Working Group 10 within ISO to "...take into account the existing product, the new technologies (such as LED) and new opportunities regarding on board electric power given for example by EPAC/Pedelec." ISO 6742 parts 1-5 which includes in part 2 a standard for retro-reflective devices.

The Working Document is not publicly available at the moment⁸², though ISO Standard ISO 6742/1 for lights is thought to contain the following parts

Part 1: Lighting and signalling devices

⁷⁹ <http://www.beuth.de/de/norm/din-33958/148221878>

⁸⁰ http://wetten.overheid.nl/BWBR0009295/geldigheidsdatum_06-04-2009#3

⁸¹ <http://www.raivereniging.nl/activiteiten/keurmerken/keurmerk%20fietsverlichting.aspx>

⁸² But can be found here

http://www.jbtc.or.jp/current/data/menu_03/3/iso/ISO_CD_6742_Part_1.pdf

http://www.jbtc.or.jp/current/data/menu_03/3/iso/ISO_CD_6742_Part_2.pdf

http://www.jbtc.or.jp/current/data/menu_03/3/iso/ISO_CD_6742_Part_3.pdf

http://www.jbtc.or.jp/current/data/menu_03/3/iso/ISO_CD_6742_Part_4.pdf

http://www.jbtc.or.jp/current/data/menu_03/3/iso/ISO_CD_6742_Part_5.pdf



Part 2: Retro-reflective devices

Part 3: Installation and use of retro-reflective devices and lighting devices

This part of the ISO 6742 applies to lighting and signalling devices used on cycles intended to be used on public roads and, especially, bicycles complying with ISO 4210 and 8098.

This part of ISO 6742 prescribes the safety requirements and test methods of lighting and signalling devices for:

- fastening devices
- control
- instructions for mounting and use

Part 4: Lighting powered by the cycle's movement

Part 5: Lighting not powered by the cycle's movement

CEN Standards

There are no CEN European standards of bicycle lighting; there are standards for bicycles which require that reflectors and lights conform to whatever approval applies in the country where the bicycle is sold. EN14762 states

"No requirements on lighting equipment, reflectors and warning devices are specified in this European Standard, due to the existence of several different national regulations applicable in the European Countries."

If CEN are asked to provide an EU standard they would be obliged to take that standard from the current work that is going ahead in ISO, this standard would then have to be accepted as the national standard in each country.

European Union

There is as of yet no European Standard, however 2011/786/EU "Commission Decision of 29 November 2011 on the safety requirements to be met by European standards for bicycles, bicycles for young children, and luggage carriers for bicycles pursuant to Directive 2001/95/EC of the European Parliament and of the Council" does state;

"Part 1, Section 1

1. General requirements:

"Bicycles shall be equipped with lighting equipment and reflectors at the front, back and at the sides to ensure good visibility of the bicycle and of its rider. These devices shall comply with the provisions in force in the country in which the product is marketed."

6. Product safety information

"Safety information shall include instructions on how to position reflectors and lamps to ensure maximum visibility, according to the provisions in force in the country in which the product is marketed."

During the European Parliament 'Road Safety Report' last year coordinated by MEP Koch, concluded with regard to bicycle lights for a call "...minimum requirements in respect of lights and reflective devices which must be met by bicycle manufacturers." However could be said to be met already by CEN bicycle standards.



Consumers - viewpoint of bicycle and cyclist associations and user groups on traffic regulations as well as an EU lights standard

ECF sent a survey to their members asking for their traffic regulations and also whether there was a national standard for bicycle lighting and reflectors. We also asked them if they had an opinion on whether the traffic regulation was appropriate and what they thought about an EU standard for lighting.

Austria - would prefer to have less light requirements in their country. Equipment requirements could be simplified from the 2 lights and 10 reflectors currently required. E.g. lights plus reflectors would be enough. Regarding standardisation they thought that it would be a good idea to have a European standard because a harmonized technical standard for lights would provide clear labelling on products saying that they meet legal requirements. Current definition of headlights in Austria regarding light output in candela for example is problematic, since this differs from definitions in Germany.

Belgium - thought that a standard would be a good idea though more information would be needed. "Standards should help cyclists to buy good quality equipment but if it is an obligation to purchase a particular material, what about the cost? Cost must remain easy and cheap for the cyclist to equip himself according to standards."

Bosnia and Herzegovina - thought that there must be a better way to allow or persuade regulators and manufacturers to provide bicycles with lights to allow for better safety. They thought that lights could be a good way of promoting responsible safety by the cyclist rather than relying on helmets or reflective clothing with all their attendant problems. As a cycling developing nation currently outside the EU it would be useful to have a good standard that they could follow.

Bulgaria - thought that "Lights are very important for the security of the cyclists. Often the short life of batteries or the lack of good quality 'dynamos' is an oft-cited reason for cycling without proper lights. Better hi-tech products with less power consumption will be a welcome addition to the market". They thought that if there to be a European standard it would be easily accepted and applied in Bulgaria.

Czech Republic - Dynamos as the main bike light should be applied as regulation in the Czech Republic.

Finland - thought that there is no need to change the legislation in Finland but as regards standardisation they thought that given the variety of bicycle lights sold and the difficulty of knowing the brightness and quality of the light an international standard would be useful.



France - The French thought that stronger regulation is needed in France. They thought that the French consumer is not really knowledgeable of the difference between a good light and a bad light, and since commuting bikes tend to be much cheaper than the racing style of bike the cheapest light is often bought to go on it. They thought that a European standard would be a good idea.

Germany – A survey carried out by ADFC⁸³ on German attitudes to bicycle lighting found that

- 62% of cyclists use dynamo lighting; 22% battery
- Only 22 per cent said they had not had problems with battery lights and 70 per cent said this about dynamo lights
- in Germany, even with its long tradition of dynamo lights 53 per cent are in favour of allowing battery lights

Regarding an EU Standard ADFC thought that countries with a low standard could benefit from an EU standard, but the standard should not be too low, otherwise it will not be accepted by those countries with a high standard.

Iceland - Iceland thought that promotion and information would be more preferable to further national regulations. With regards to an EU standard if it were too high it would deter people from using it or could even stop people from cycling.

Italy – there should be better stronger light requirements and better enforcement.

Romania - thought that existing Romanian regulations were enough, though perhaps "...a minimum light intensity requirement for front and rear light, to exclude from the market very poor quality bicycle lights" would be useful. They thought that reflectors on pedals should not be mandatory (as they are now), and reflective vests or reflective elements on clothing are not desirable to become mandatory or standardised. EU standard for lights would, in principle be a good idea, however since some countries have strict regulations it is likely that an EU wide unitary regulation would not have the effect of de-regulation in these countries, but would rather lead to an EU wide over regulation raising the standards everywhere to the highest levels now existing in some countries that are exaggerated and would not be to the benefit of cycling.

Slovenia - It would be useful to have the legislation more or less harmonized in all EU countries, but should be really well prepared on broad democratic basis.

United Kingdom – Thought that there should not be tighter regulation, rather there should be de-regulation "...to go back to the simple white in front, red behind requirement for lights that "can be seen from a reasonable distance that we had in the 1970s". For a little while in the 1980s, British-made British Standard battery lights ruled the UK market and also sold well abroad. But from the 90s onwards, smaller,

⁸³ Allgemeiner Deutscher Fahrrad-Club e. V. German national cycling association



lighter, cheaper, non-approved but actually much better battery lights from the far east flooded onto the market, whilst cycling reduced in Britain to the point where there was point in seeking BS approval for a lamp because it was good for only one small market where it was easy enough to sell an un-approved lamp anyway”.

This means that currently the majority of UK cyclists are riding illegally at night (even though their lights are sufficient) because their lights do not conform to the BS6102. However the Police and enforcing authorities are happy so long as there is a light on the front and back of the bicycle. The problem is, apart from the law coming into disrepute, is that the illegal nature of perfectly good lights undermines the cyclists claim for damages following an incident. Approval also becomes more important when a bike is sold complete with lamps. The retailer is liable to prosecution if they are not approved, so the difficulty of sourcing approved lights discourages the sale of bikes complete with lamps.

With regards to an EU standard this would be a good idea, however, it would have to be very unrestrictive with regards to its design. It must not favour dynamo lights or battery lights but must allow all those who design good lights to be incorporated. There is concern over the current ISO process that the draft standard as it stands will not be much use in countries that mainly use battery lights (UK, South EU, East EU). Many battery lights are bright enough and good enough for most cyclists, but they would not conform to the ISO draft that has been prepared. It has not incorporated the participation of manufacturers of really good battery lights. Therefore the standard will have no credibility amongst those who use battery lights (i.e. all countries that do not border Germany). The specifications of the battery lights part of that standard is tied up too tightly and too design restrictive. Cyclists in those countries will not be grateful for an EU standard that fails to recognize their perfectly adequate lights.

Ukraine – They are satisfied with the current requirements for Ukrainian regulations for lights on bikes. If requirements were stronger, many cyclists, particularly in rural areas would become criminalized.

Conclusion

- Some with high regulations on lighting thought that it should be simplified while those with less regulations though it could be tightened
- Enforcement was also raised
- Traffic regulations should not deter people from cycling
- many seem to agree that given the variety of bicycle lights sold and the difficulty of knowing the brightness and quality of the light a standard could be a good addition to cycling safety in their countries,
- there are however proviso's
 - The standard must be flexible enough to cope with the myriad forms of lighting around Europe
 - If the standard is too exclusive towards expensive lights then perfectly good cheaper lights could leave cyclists legally liable even if their lights are perfectly good



- A too high standard would mean little take-up, there could be problems in countries where bikes are costing 200-300 Euros if the lights cost 10-15% of the total bicycle price (or even more, a good hub dynamo costs about €80)
- Too low a standard would have less effect on road safety and would mean de-regulation in those that have high standards
- There is also concern about a standard being too complicated, this could stop good product development, and smother any interest that manufacturers would have in a standard. Specifically this criticism comes from the UK concerning how the current ISO work is making the design of battery lighting too design restrictive. If this continues the standard will not recognise many useable battery light design and will therefore be undermined in those countries that mainly use battery lights (such as the UK, South EU, East EU)

Producer's viewpoint of an EU standard

The industry is in favour of a standard and is currently working on this standard at the level of ISO.

Lighting and Reflector Systems- proposals regarding possible EU standard

These proposals are based on research and also on the following documents:

-German Light standard DIN 33958 2012-02

-DEKRA NL Netherlands Issue 9 July 2012

-Draft ISO 6742-1 t/m 6742-5 (a draft not public yet, but available on the internet⁸⁴)

The standard can be used:

- For national traffic law and regulations to refer to
- As an indication to the consumer about the product quality

The best practical solution for an EU-standard would be to have the primary requirements described in national law (such as the position of the light, whether flashing lights are allowed, etc.). If the national legislator needs quality requirements, the law should then refer to the EU standard. For example if it is deemed a requirement of German law that a headlight must be powered by a dynamo, and that

⁸⁴ But can be found here http://www.jbtc.or.jp/current/data/menu_03/3/iso/ISO_CD_6742_Part_1.pdf
http://www.jbtc.or.jp/current/data/menu_03/3/iso/ISO_CD_6742_Part_2.pdf
http://www.jbtc.or.jp/current/data/menu_03/3/iso/ISO_CD_6742_Part_3.pdf
http://www.jbtc.or.jp/current/data/menu_03/3/iso/ISO_CD_6742_Part_4.pdf
http://www.jbtc.or.jp/current/data/menu_03/3/iso/ISO_CD_6742_Part_5.pdf



only a headlamp is allowed that meets the EU standard for low beam, this can then be referenced to the standard.

Although at first it seems to make little sense to have low requirements in the standard, if a country does not want to set high requirements on lighting, then it need not refer to a standard at all. However a possible problem with this could be if a country wishes to have lights fitted to the bike at the point of sale and a standard is used this may push up the price too much in those countries where a bicycle costs only 200 euros or less. Lighting costing 10-20% of the bike sale would limit bike sales and/or discourage the sale of bikes complete with lights.

There should be flexibility so that dynamo lights and battery lights are both incorporated. A standard should be like a menu in a restaurant! Different dishes can be chosen, but whatever is chosen, it will be of a sufficiently high quality

Requirements can be split into:

- Photometric requirements
- Technical requirements for reliability (to be sure that the light still works when riding in heavy rain, at -15 and/or over cobblestones.)
- Information for the consumer/dealer

The main requirements of the three standards

Headlights

Visibility; being seen

The main requirement of a headlamp is to be seen.

The requirements are described in DEKRA NL 6.1.4, and ISO 6742-1 4.2.1. ISO is slightly stronger. DIN gives no requirements for visibility. It seems logical to use the ISO requirements. All three give a maximum of 200cd (= 2 lux at 10m) to avoid glare. In ISO only a lamp specially designed for visibility must meet these requirements (or it is not well defined). It seems logical that the requirements should apply to all headlights.

Illumination of the road, low beam

DIN 4.1.2.1, ISO 4.5.1 and 6.1.4 DEKRA NL give the same requirements for headlights. At least 1000cd minimum at the centre (= 10 lux at 10m) and requirements on the shape of the beam. At DEKRA NL lights with at least 400cd and 700cd can be approved. However a problem with this is that with these values the output for illuminating the road is low but the headlight could easily be improperly adjusted with a high beam, which can then dazzle oncoming traffic. It is unclear whether a lamp with max output between 200cd and 1000cd in ISO may be approved as lamps only to be seen rather than for illumination of the road.

DIN and ISO have separate requirements for headlamps with a maximum of more than 20 lux.



Illumination of the road, high beam

This would not seem to be useful since such a light is generally not allowed in traffic (cycling with a light is possible, but it must be turned off when encountering oncoming traffic. So it is not a product for use in traffic)

Flash light

In DIN and DEKRA NL flashing lights are forbidden (illegal in Germany and the Netherlands). In ISO a low beam must emit light continuously. ISO gives requirements for the flashing frequency in 4.2.2 and requirements for the effective intensity in Annex A. It is unclear in ISO if a lamp with different flashing mode must meet the requirements in any mode, though it would seem logical to do that.

Stand Light

DEKRA NL makes no demands on the stand light. ISO 4.8.1 allows very low demands on the stand light (seems to be the value of DIN for the rear light). Recommendations in DIN 4.1.3 are that it must operate for at least 4 minutes.

Lifetime of batteries

This is not yet specified in ISO 6742-5 (possibly because this is a difficult discussion). DEKRA NL only indicates that a battery-low indicator is required. For the DIN it must be 5 hours (for lights with low beam), if the indicator shows that a battery change is necessary, it must have at least 0.6 cd for 30 minutes.

It would seem logical to use the DIN requirement for low beam headlights. For headlights just to be seen, a lifetime of 20 hours seems reasonable. Most of the lights that are only 'to be seen' have no low battery indicator. It is unknown if it is possible to have one without adding an extra led. (By example if when turning on the light and the batteries are too low there is a flash for a short period).

Light output at low speed

ISO 6742-4 5.1 gives the values at different speeds. Test speed is 15 kph, under 5 kph there is no value, between 5 and 15 kph the value is derived from 4.2.1. That seems reasonable but is technically very difficult with a normal headlight. Because the energy input falls, the light output also falls. So if a light at 15 kph just meets the requirements, at 5 kph it will never meet the requirements. The only solutions are a more powerful headlight or light with extra LEDs for visibility and at low speed only power these LEDs. (Possible problem here with ISO)

Rear light

Light output

DEKRA NL 6.2.3 is a three star system. ISO 4.3.1 and DIN 4.2.2 requirements are similar to the two stars of DEKRA NL. It would seem logical to take this value. ISO gives 200cd as max. DEKRA NL and DIN gives 12cd. (200cd may be a mistake in ISO.)



Stand Light rear light

DIN 4.2.3 gives the requirements for the stand light. This is recommended.

Flashlights

ISO gives requirements like the requirements for the headlight. T This is recommended.

Battery Life

DIN 4.2.4 gives at least 15 hours. That seems a little bit low, we recommend 20 hours.

Reflectors

DEKRA NL 6.2.6 only gives requirements for the rear reflector and is the same as DIN 4.4.3.2. ISO 6742-5 is a little bit different from DIN 4.4.3 though not enough to be important.

It does not seem necessary to require a reflector to be integrated in the headlight or rear light. If countries wish to have light reflector integration this can be registered in national regulations.

Dynamo

DIN provides detailed requirements for dynamos. This could be recommended.

Colour

All three use the same detailed requirements for colour headlight and rear light. This could be recommended.

Stoplight

ISO gives requirements for the stoplight (though this is very rarely used with bicycles). Requirements are a minimum of 40cd and a maximum of 185cd. This could be recommended.

Direction Indicators

ISO gives requirements for the indicators (though this is rarely used with bicycles). Requirements are a minimum of 50cd and a maximum of 350cd and requirements on the beam shape and frequency. This could be recommended.

Durability / Reliability

DEKRA NL just gives a vibration test. ISO has a more extensive list that still seems to be on-going.

DIN gives the common tests for durability (corrosion, water, shock loads, vibration load). This could be recommended.

Information for the consumer

In all three standards there are no requirements for the information for the consumer (maybe typical for standards. If a product meets the requirements of the standard it is good and no further information is needed)



However it seems reasonable to have the following technical performance given to the consumer.

- Output in lumens or power/current used by the LED
- Lux max
- For batteries: the time of the light that meets the requirements
- Type of LEDs used
- Light output as function of speed or battery life

We would also recommend possibly finding a way to outlaw unrealistic and over optimistic runtime of batteries and distance visibility.

Other items for consideration (mainly about the headlight):

- Minimum battery runtime (or must manufacturers just specify the runtime according to a particular test)
- Should there be a standard for a high beam?
- What to do with headlights that give more than 200cd and less than 1000cd as maximum (2 and 10 lux at 10m).
- Light output of dynamo lights at low speed and light output of the stand light
- What information should manufacturers include about the performance of their products?
- Should visibility only lights have a low battery indicator

Positioning of lights

Should the standard demand that lights must carry instructions on where to fit them on the bicycle? Commission Decision (2011/786/EU) on safety requirements to be met by European standards for bicycles, bicycles for young children and luggage carriers for bicycles, although not specifically for lights, states that

"Safety information shall include instructions on how to position reflectors and lamps to ensure maximum visibility, according to the provisions in force in the country in which the product is marketed"

If the lights are sold with the bicycle then a similar clause for the product safety information with bicycle lights would perhaps not be useful however many lights are bought and fitted independently from the sale of the bicycle, perhaps then it would be in the spirit of the Commission decision to have a clause in a European standard on how to position the lights, as part of the product safety information

Further research needs - To identify further research needs.



- As explained in the traffic accident statistics section (and as always with cycling) we need comprehensive exposure figures. Figures that do not accommodate distance travelled or trips taken make it difficult to make decisions on risk in cycling and also do not allow for comparison across modes
- The current work being carried out at the level of ISO needs to be known. This work seems to currently be in an advanced stage.