# Comparative life cycle assessment of LED lamps based on cadmium containing quantum dots and conventional phosphors prepared for Lumileds

## Preliminary Report

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# Goal and scope

# Goal and scope of the study

**Goal:** To compare the environmental impacts of cadmium-containing quantum dot LED lamps with current conventional phosphors LED lamps in general illumination applications.
**Scope:** "Cradle-to-grave" assessment

**Configurations of the lamp under study:** LED replacement for 60W incandescent lamp (12 LED packages for 843 lm, 2700K, CRI 90) with a lifetime of 20,000hr. Three different configurations are being compared*:

- LED lamp with LED packages using current conventional phosphors (as baseline),
- LED lamp with LED packages using green phosphor and red quantum dots (first generation) with 12% increase in efficacy,
- LED lamp with LED packages using green phosphor and red quantum dots (second generation) with 25% increase in efficacy.

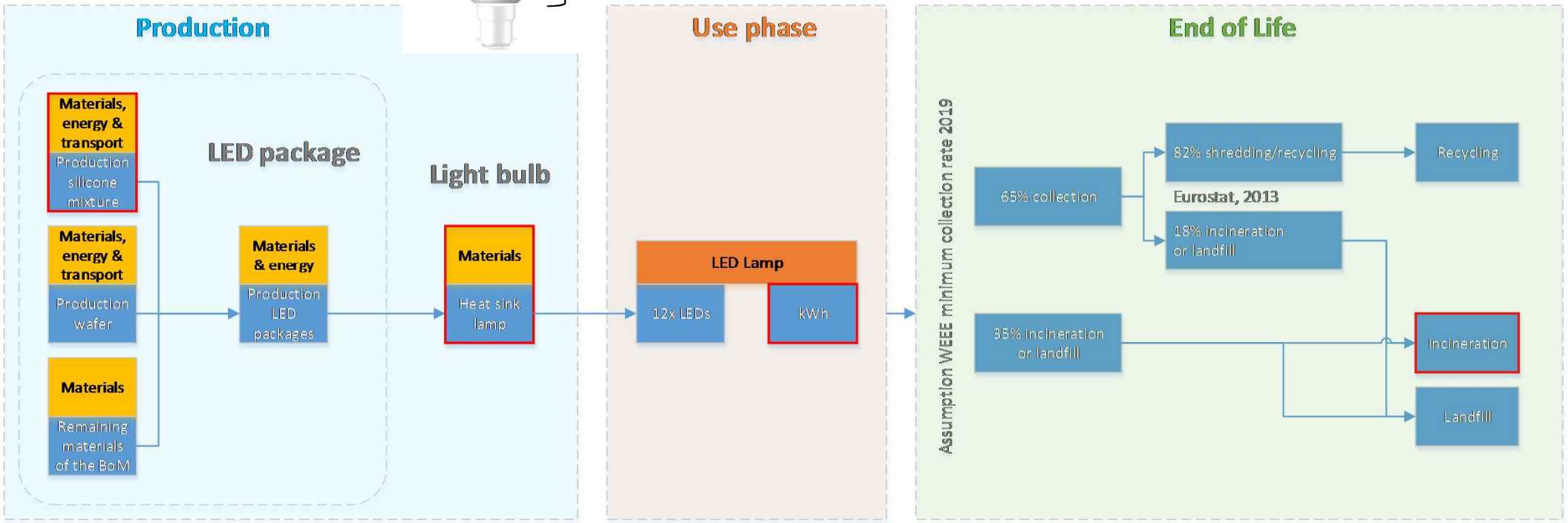
**Basis of study**:

- The LED packages with quantum dots have a higher efficacy and can be operated at a lower current. The light output per LED package does not change. The number of LED packages is the same for all configurations.
- The size of the heat sink in the lamp can be reduced when the efficacy increases.
- Other parts of the lamp, such as optics, screw cap and electronics will remain unchanged. They are not considered for this assessment and are out of scope.
- Transport of the product to the customer and to the disposal facility at end of life is the same** for all configurations assessed. Those transport steps are not considered for this assessment and are out of scope.

* The given efficacy improvements are estimates based on internal data and roadmaps for the given CCT/CRI combination relative to current conventional phosphors. The second generation is expected to replace the first generation of quantum dot LEDs within a year.
** There would actually be a small difference due to the reduced weight of the heat sink, but this is negligible.

# Scope of the study


Heat sink




Key differences between conventional and quantum dot based lamps

In this presentation, LCA results reflect the end of life scenario of incineration of LEDs only, as it is considered as the worst case scenario of disposal (Aluminum is considered collected for recycling before incineration)



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# Data used for modelling and LCA methodology

- Background data is taken from the Ecoinvent database (http://www.ecoinvent.org/home.html).

- The LCA methodologies used to interpret the results are the:
  - ReCiPe methodology for LCA (http://www.lcia-recipe.net/)
  - ILCD 2011 Midpoint+ methodology for LCA (http://eplca.jrc.ec.europa.eu/uploads/LCIA-characterization-factors-of-the-ILCD.pdf)



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# First results of the Life Cycle Assessment

# Summary of main conclusions

The LCA results are in favor of the cadmium containing quantum dot LED lamps when compared to current conventional phosphor LED lamps. The environmental impact of cadmium in the LED packages is negligible when looking to the total life cycle impacts.

Increases in the environmental impact of quantum dot LED lamps, compared to current conventional phosphor LED lamps, come from two phases:

- In the production phase the impact increases for the quantum dot LEDs due to the higher energy needed to produce the quantum dots (compared to conventional phosphors)
- In the end of life phase, when incinerated, the cadmium released into air increases the impacts of the quantum dot LEDs

The increase of impacts in these two phases is outweighed by the reduction of impacts in other phases of the life cycle, namely:

- In the use phase, thanks to the increase in energy efficiency of the quantum dot LED lamp, less electricity is needed over the lamp lifetime compared to the conventional LED lamp.
- In the production phase, the weight reduction of the aluminum heat sink for the quantum dot LED lamp reduces the environmental impacts compared to a current conventional phosphor LED lamp.
- If the aluminum heat sink is not collected for recycling before a lamp is incinerated, an additional benefit comes from the lower quantity of aluminum being incinerated (this preliminary report assumes heat sinks are removed before incineration).

| **Impact reduction or increase per phase compared to a current conventional phosphor LED lamp** | **First generation of quantum dot LED lamp** | **Second generation of quantum dot LED lamp** |
|---|---|---|
| Production | -5% | -12% |
| Use | -11% | -20% |
| End of Life | +2% | +2% |
| Total* | -11% | -20% |

* The total impact is determined primarily by energy consumption during the use phase (details are given on next slide)



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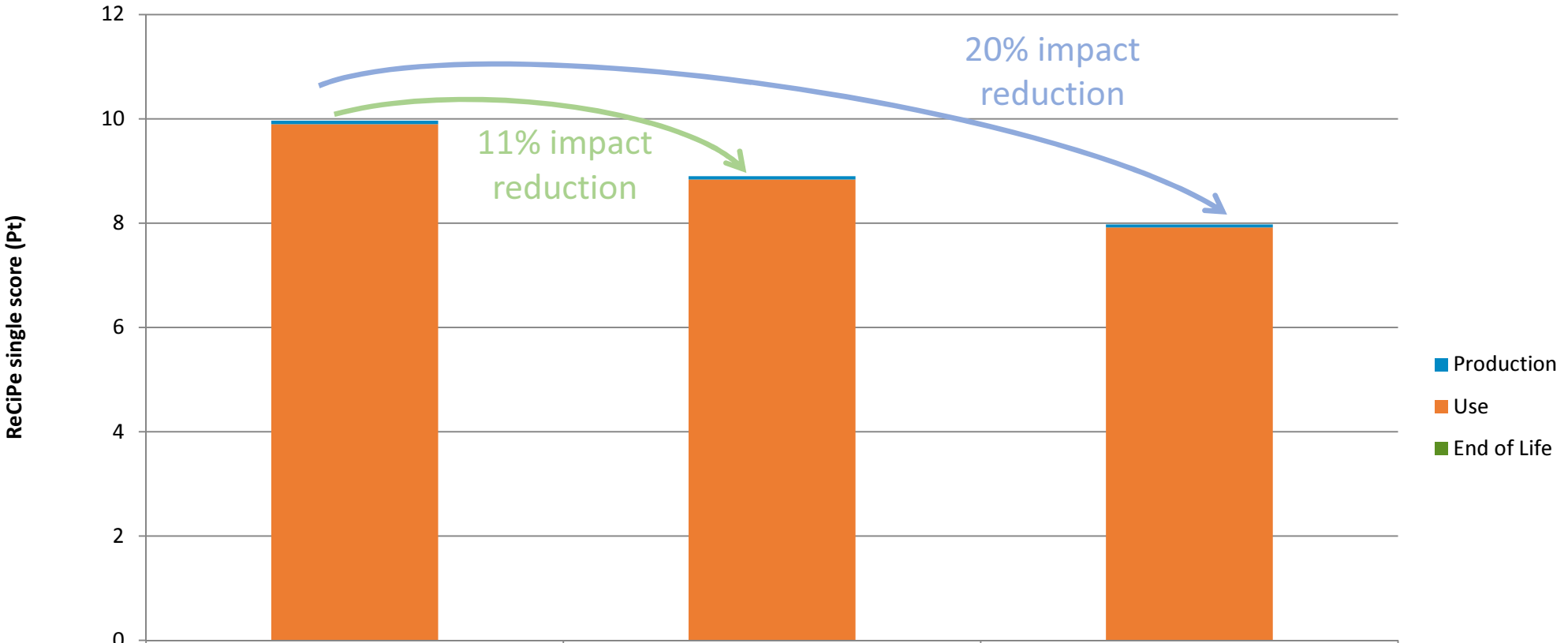
# Impact reduction over complete life cycle with the ReCiPe methodology for LCA




| | Lamp with conventional LEDs | Lamp with LEDs quantum dots (first generation) | Lamp with LEDs quantum dots (second generation) |
|---|---|---|---|
| Production | 0,0674 | 0,0640 | 0,0595 |
| Use | 9,8984 | 8,8362 | 7,9160 |
| End of Life | 6,05E-05 | 6,20E-05 | 6,20E-05 |



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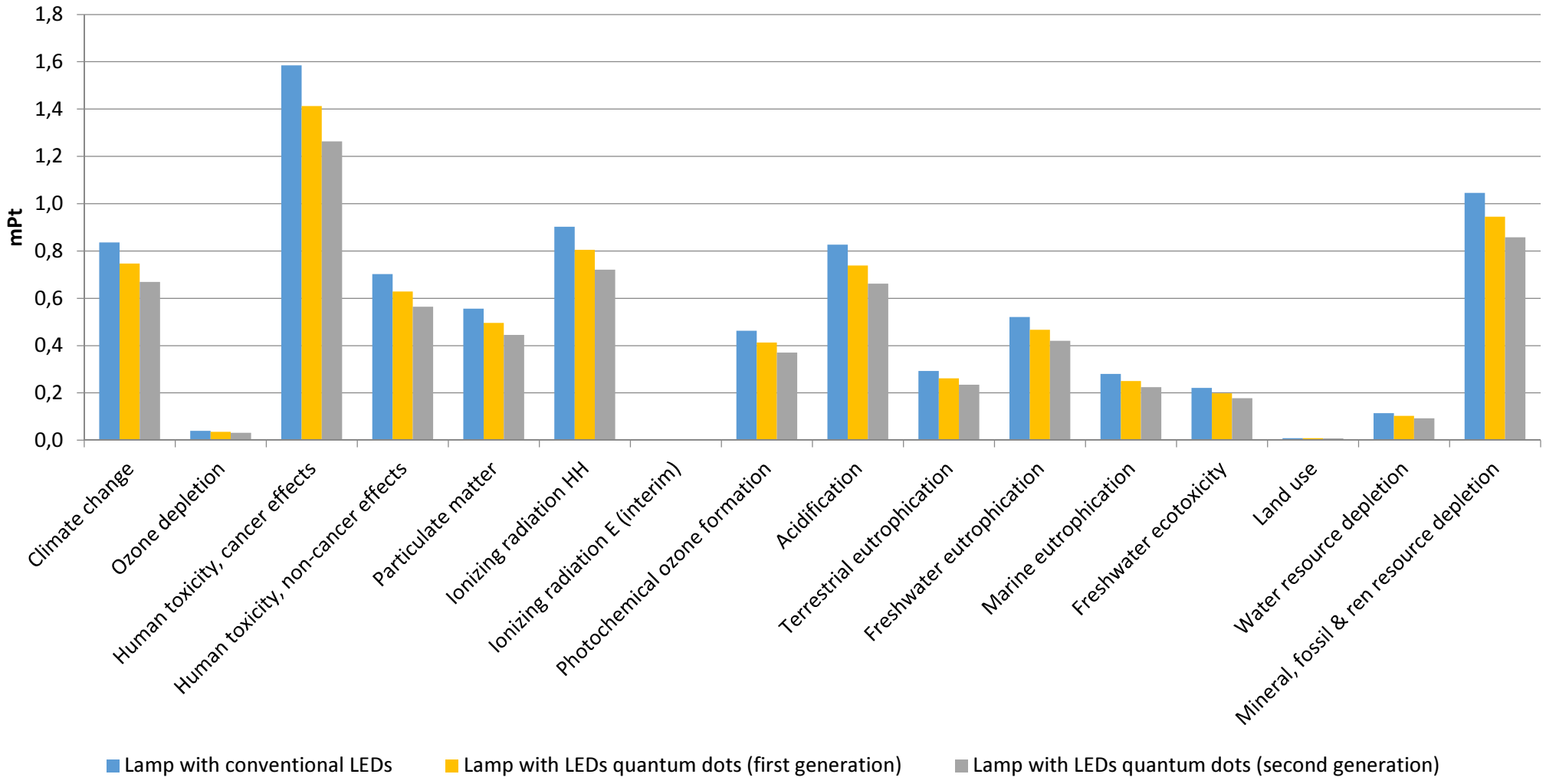
# Impact reduction over complete life cycle with the ILCD methodology for LCA



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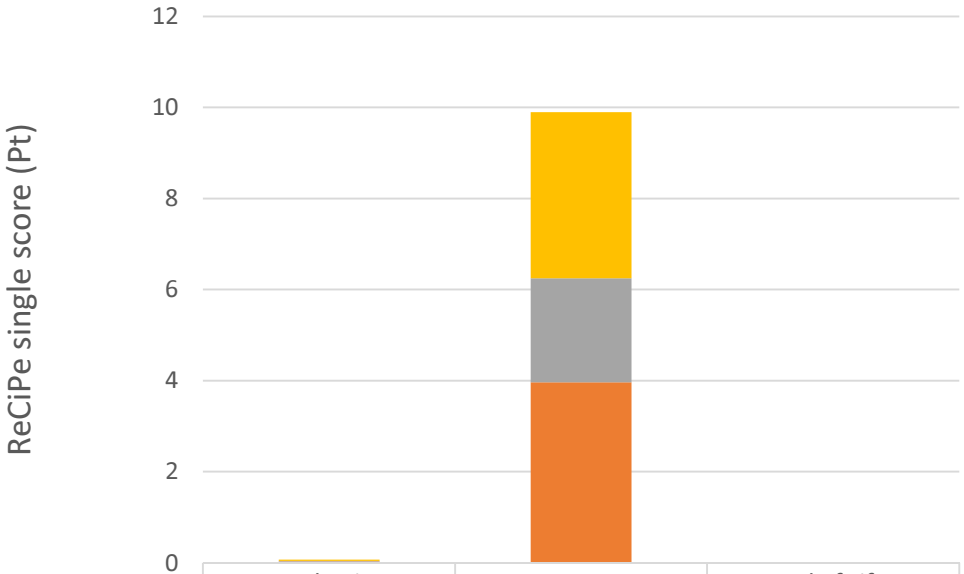
# LCA results per life cycle step

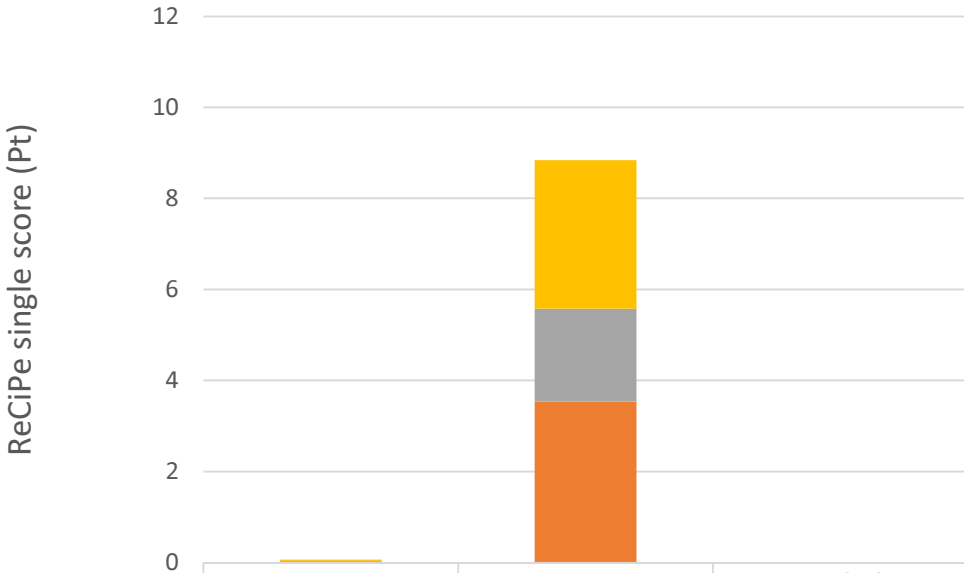
LED lamp using conventional phosphors




| | Production | Use | End of Life |
|---|---|---|---|
| Resources | 0,0288 | 3,6507 | 1,17E-05 |
| Ecosystems | 0,0136 | 2,2851 | 1,86E-05 |
| Human Health | 0,0250 | 3,9626 | 3,03E-05 |

Human Health Ecosystems Resources

LED lamp using quantum dots (first generation)




| | Production | Use | End of Life |
|---|---|---|---|
| Resources | 0,0278 | 3,2589 | 1,16E-05 |
| Ecosystems | 0,0128 | 2,0399 | 1,86E-05 |
| Human Health | 0,0234 | 3,5374 | 3,18E-05 |

Human Health Ecosystems Resources



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# External review



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# Review of LCA for comparison of 2 LED technologies

Performed by J. Coustillas, Pré Consultants bv

# Review summary

- Review performed as an on-going process at each stage of the study

- Performed on the following aspects
  - Goal and Scope
  - Bill of material & Production data
  - Electricity use
  - End of life assumptions and test results

# Review summary – Main comments

The following comments have been made, and were integrated in the study:

- An alternative assessment with the ILCD method should be presented.
- Missing data shall be estimated using closest as possible proxies, and assumptions taken should follow a sensitivity test if their contribution is important
- Uncertainty data or estimates should be gathered for the most important contributors and assessed in the final report

Other small remarks were made but prove to have little influence on the results

A detailed review file will be submitted with the final report.


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