Case study: A study of cases

Aalto University, School of Arts, Design and Architecture
Department of Design, Creative Sustainability
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[redacted]
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Smartphones may be smart, but they are hardly sustainable. Not even in the durability sense of sustainability. To keep my dear device running and alive at least a little longer I, like many others, use a protective case. This case study explores the environmental impact of mass-produced smartphone cases and examines local additive manufacturing as an alternative.

Basic data

- Phone model: Google Nexus 5, manufactured by LG
- Weight of original case: 19 grams[1]
- Weight of original case packaging: paper - 24 grams, clear PET - 7 grams, blue PET - 10 grams[2]
- Estimated weight of 3D printed case: 20 grams

Fig 1. Original Nexus 5 bumper case

[1] https://play.google.com/store/devices/details/Nexus_5_Bumper_Case_Gray?id=nexus_5_bumper_case_gray

[2] Measured by author.

Fig. 2: Original case packaging

Fig. 3: Visualization of a 3D printed Nexus 5 case[3]

[3] http://www.thingiverse.com/thing:333230

Assumptions and limitations

- Original case is shipped to Berlin, Germany. The 3D printed case is manufactured there as well.
- Recycling scenarios are based on Berlin as location. Everything but the paper from the original case is combusted, the paper is recycled. The plastic used for 3D printing is recycled to 90%.
- All the materials for the original case are virgin materials except the blue PET which has 50% recycled content.
- The case and packaging are produced in and shipped from Chuagdong, China.[4] They are transport by sea freight to Rotterdam where they are loaded onto a big truck that takes them to Berlin. So called last mile delivery is not considered.
- Acquisition or degradation of production equipment is not considered for either case.
- Since it does not have any big volumes where density can be reduced, the 3D printed case would have to be made a solid object.
- The 3D printed case is made from PLA plastic with 50% recycled content.[5]
- The PLA material is made in Germany and shipped to Berlin on a small truck.[6] The transport of the material to the retailer is not consider, just like the transport of materials to the factory is not considered for the original case.
- Energy consumption for 3D printing solid objects with PLA is roughly 20% higher than for industrial injection molding of the same object.[7]

Fig 3. Assumed shipping route from Chuangdong

[4] http://www.made-in-china.com/products-search/hot-china-products/Google_Nexus_7_Case.html
[5] http://www.absplastic.eu/pla-vs-abs-plastic-pros-cons/
[6] https://shop.germanreprap.com/de/PLA-Kunststoff-2-1kg-1-75mm-schwarz
[7] Krieger, M. & Pearce, J. M. (2013). Environmental life Cycle Analysis of Distributed Three-Dimensional Printing and Conventional Manufacturing of Polymer Products. *ACS Sustainable Chem. Eng., 1*, 1511-1519.

Life-cycle analysis results

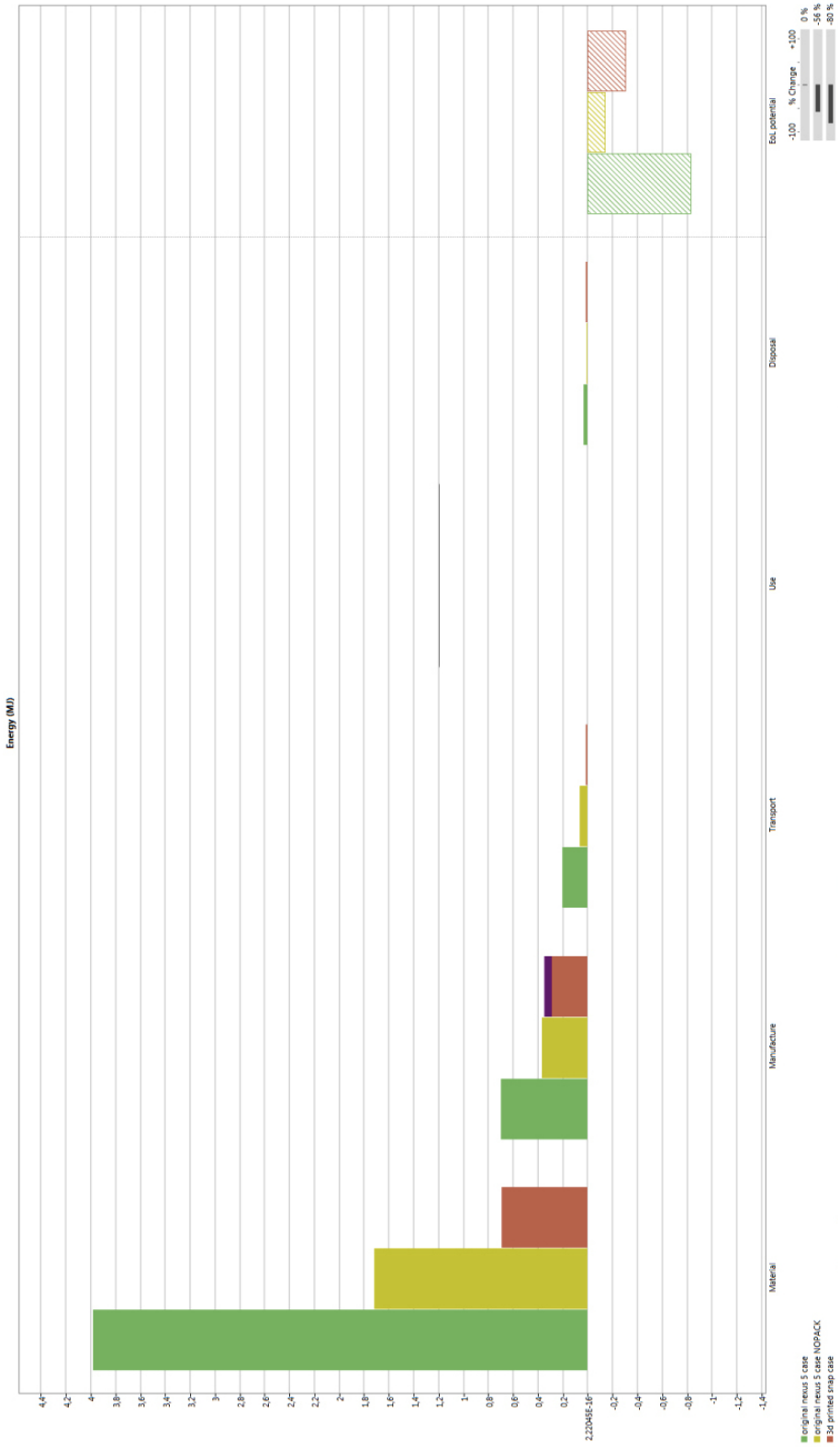

Fig 4. Energy eco audit using CES Selector 2014. Purple block adjusts for 3D printing.

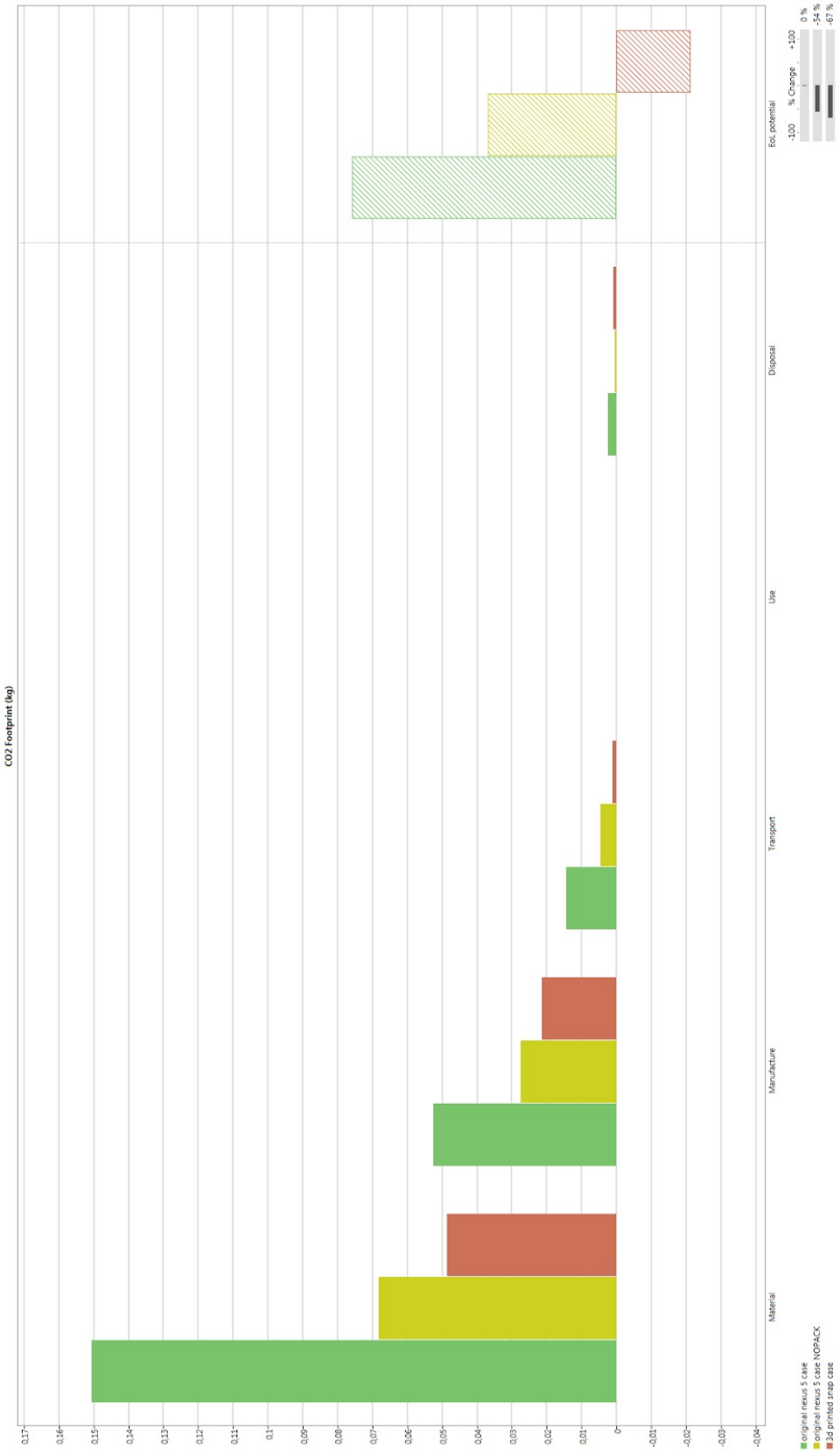

Fig 5. CO_2 eco audit using CES Selector 2014.

Conclusions

And the winner is… 3D printed case! The margin is not very big, but it is clear from the eco audit that the 3D printed case consumes less energy and generates less CO_2 emissions throughout its lifetime.

At a quick glance the graphs also reveal that the biggest chunk of environmental impact for both case options are caused by the source materials. Both in energy used and CO_2 generated, the materials generate significantly more impact than all other life cycle stages taken together. According to LCA experts, the most impactful factor in 3D printing scenarios is the choice of base material.[8]

The third obvious and noteworthy conclusion is that the packaging of the original case is a major driver of environmental impacts. Without packaging, the impact of the original case is reduced roughly by half. Taking the packaging out of the calculation makes a much bigger difference than the change from mass-manufacture injection molding to local 3D printing.

Not surprisingly, the 3D printed case claims its biggest victory in the transport phase. But it must be noted that the impact of transport for either of the cases is relatively small compared to materials and manufacturing. Another technicality to keep in mind here is that the packaging of the original case adds not only weight but volume, which means that fewer units can be transported in the same space.

One thing that could affect the comparison is that the original case might have better durability and thus not need to be replaced as soon as the 3D printed one. But even in an extreme case where the original case would last twice as long as the 3D printed one, the latter emerges as the more sustainable option. Two 3D printed cases are very roughly speaking on the same level of impacts as one original case without packaging.

From a consumer and user point of view, the factors of convenience, price and aesthetics come into play. With the assumptions that original cases are available on stock in Germany and that the PLA plastic is available at the point of printing, delivery time will not differ significantly. Convenience is much higher for the original case however it requires a minimum of effort between purchasing online and receiving the shipment. The 3D printed case requires the consumer to seek out or create a suitable 3D model file and then be present at the printing location. Bearing this need for know-how and engagement in mind, it seems unlikely that any consumer will face a situation where convenience is not the deciding factor in the choice of case. On the other hand, the consumer price would be significantly lower for the 3D printed option. In terms of aesthetics the two cases are very different. Again, this indicates that few people who are not very interested in 3D printing technology will consider any other option than the original case (or a third party mass manufactured case).

[8] http://www.ecosmagazine.com/?paper=EC13276

3D printing is an emerging technology and it is likely to undergo significant development in the next decade. It is likely that the efficiency of 3D printers will improve, both in terms of material and energy consumption.[9] This will improve the eco audits of 3D printed products. The finish, durability and overall quality of 3D printed products will also increase, closing the gap to traditional industrial manufacturing in terms of market desirability.

Another question worth considering is whether the benefits indicated in this analysis remain if 3D printing is used on a much larger scale. There might be issues with the availability of PLA plastic for example. However, taking into account how fast 3D printing of consumer goods is developing it seems like that any inefficiencies that might come with scale would be offset by gains in efficiency through technological progress.

Finally, the key takeaways from this study:

- Even if it is a bit of a hassle, consider local 3D printing (with recycled PLA) as an option for simple plastic products.
- Absolutely avoid unnecessary and cosmetic packaging on products that do not really need it.
- Which materials go into plastic products is much more important than where they are shipped from.

[9] http://www1.eere.energy.gov/manufacturing/pdfs/additive_manufacturing.pdf