Aalto University
AAN-C2007 - Product Sustainability

Fishing rod sustainability

Team 5

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1. Functional unit definition

In order to create a greener product we must first define a functional unit to compare the new product with the old product. Our fishing rod (reel spinning rod), has as a purpose to be used around 15 times per year for 20 years (casual, recreational use) and be able to fish a 8 kg fish.

Figure 1: Picture of our fishing rod

2. Major Impacts

The biggest emission contributors on our fishing rod were the metals as seen in Figure 1 and 2. Metal production is an energy intensive process and therefore releases CO2 and other emissions. We made three different iterations of our fishing rod. The ACTUAL iteration is used as a benchmark where the other iterations are compared. The ECO version uses as much ecologically sustainable materials as possible. The PLASTIC-ECO iteration is the final iteration of our product. The PLASTIC-ECO iteration was also made to research whether it is possible to replace metals used in the fishing rod.

During these different iterations it became clear that some of the materials used in the fishing rod cannot be replaced due to functional limitations. Materials in the fishing rod need to be resistant to corrosion caused by salt water and some of the materials need to be strong and malleable. Although the stainless steel produces most of the emissions of the fishing rod, it is a superior material due to its properties.

The LC assessments were made using both open LCA and GRANTA edupack. Table 1 shows the material changes with the different iterations of our product. The materials were chosen based on the material properties of the actual fishing rod materials. An analysis was conducted by using GRANTA's tool to find a material with similar properties which is also more sustainable with its land use, water use, CO2 emissions etc. Table 2 shows other emissions associated with the product.

Table 1: Material changes

Material	**ACTUAL**	**ECO**	**PLASTIC-ECO**
Plastic cover	ABS	ABS	ABS
AL parts	Aluminum 518	PARA (45% mineral fill)	Aluminium 518
Stainless steel	AISI 316	AISI 316	AISI 316

Brass	CuZn40 C85500	CuZn40 C85500	POM
Handle	EPDM	Cork	Cork
Pole	Polyester/glass fiber	Bamboo	Polyester/glass fiber
Fishing line	PVDF	PVDF	PVDF
Nylon line	PA6/66	PA6/66	PA6/66

Table 2: Emission results of the open LCA

Emission	**ACTUAL**	**ECO**	**PLASTIC-ECO**	***Unit***	***Biggest contributor***
Acidification	0,65	0,65	0,65	mol	Polyamide
Climate change	2,98	2,44	2,68	kg	Stainless steel
Climate change biogenic	0,002	0,002	0,0001	kg	Aluminium
Climate change Fossil	2,67	2,43	2,43	kg	Stainless steel
Climate change Land use	0,002	0,002	0,00152	kg	Stainless steel
Ecotoxicity freshwater	2,39	2,27	2,32	item(s)	Lead/stainless steel
Eutrophication marine	0,36	0,34	0,33	kg	Polyamide
Eutrophication freshwater	4,21*10^-6	3,47*10^-6	3,4*10^-6	kg	Stainless steel
Eutrophication terrestrial	3,69	3,68	3,65	mol	Polyamide
Human toxicity cancer	1,90*10^-6	1,90*10^-6	1,9*10^-6	item(s)	Lead (process steam light fuel oil)
Human toxicity non-cancer	9,58*10^-8	1,04*10^-7	1,2*10^-7	item(s)	Stainless steel
Ionising radiation, human health	0,15	0,15	0,03	kBq	Aluminium
Land use	4,30	4842,28	2,50	item(s)	Bamboo
Ozone depletion	3,83*10^-7	3,83*10^-7	3,83*10^-7	kg	Polyvinylidene
Particulate matter	1,65*10^-5	1,65*10^-5	1,63*10-5	item(s)	Lead (process steam light fuel oil)
Photochemical ozone, human health	0,56	0,56	0,56	kg	Polyamide, Line production
Resources, fossil	6217,71	6206,96	6176,03	MJ	Lead (process steam light fuel oil)
Resources minerals & metals	0,045	0,045	0,045	kg	Lead (process steam light fuel oil)
Water use	0,45	0,41	0,39	m3	Stainless steel

Figure 1: Energy usage of production and manufacturing of different parts

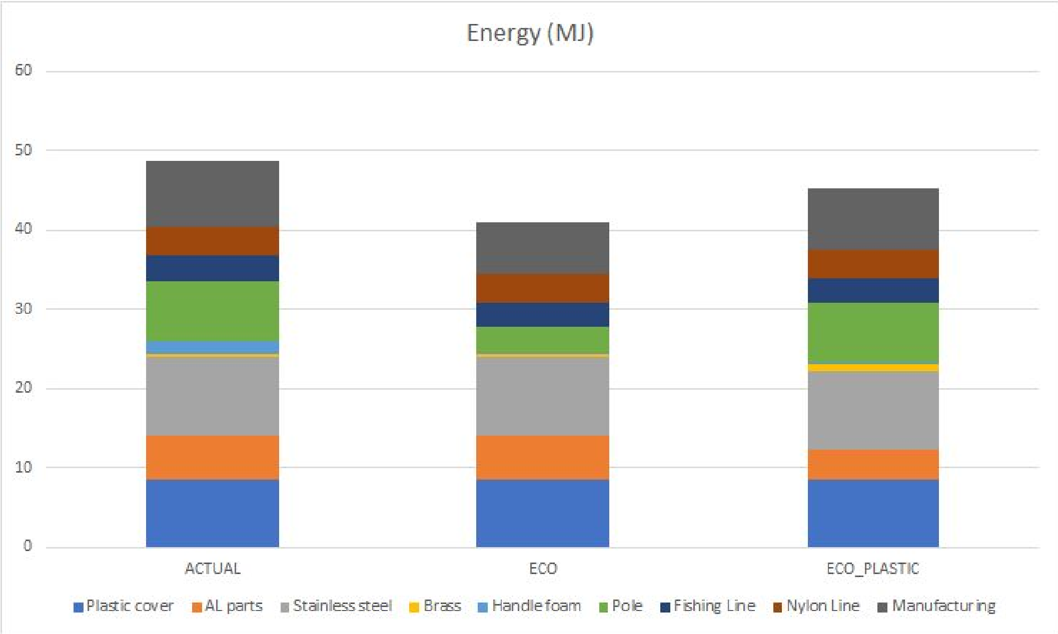
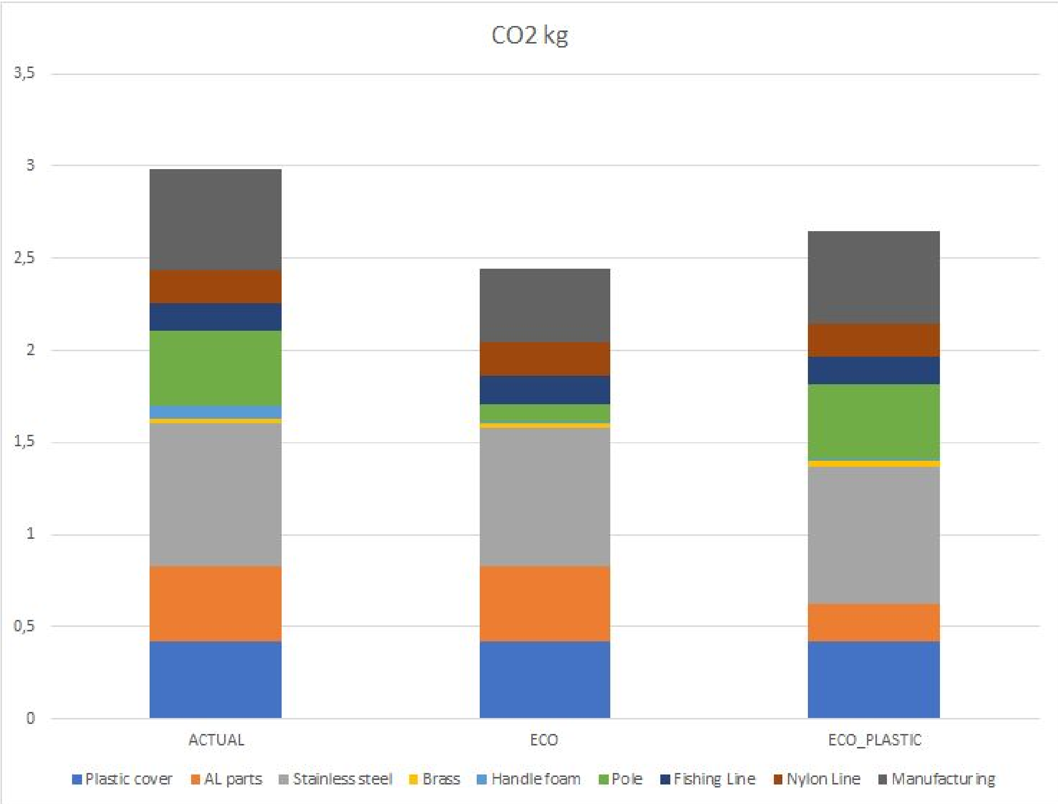


Figure 2: CO2 emissions of different parts of the fishing rod



3. Rod, Fiberglass: is it really the best material?

We try to find other materials to replace the fiberglass of the rod. Our fishing rod was made of fiberglass which has great properties: very flexible, resistant, and light. From our research we found that many new fishing rods are made of carbon fiber because it's two times lighter than fiberglass, as well as stronger and more resistant. [1] However, the recycling process for both materials is not very efficient. In both cases the fiber is covered with a resin called epoxy, the manufacturing and the product are very toxic [2]. To recycle it, it must be heated to a high temperature to melt the epoxy. The epoxy is between 35 and 50 percent of the rod. The fibers are almost intact after melting but it's very expensive to recycle it, and you need to mix it with original carbon fiber. Additionally, some tests show that some mechanical properties are lost with recycled fiber. Moreover the fiberglass dust is a hazard for breath

We find two alternative possibilities to change the rod material:
*Use bamboo, although bamboo has higher water consumption and is slightly less durable than fibreglass, the advantages are as follows: it grows 8 times faster than wood and in many environments, it releases up to 30% more Oxygen in the atmosphere than trees, 100 times cheaper than the carbon fiber [3] [4], and it produces no waste or biodegradable waste.
*Use Cleavamine degradable curing agents and Recycloset recyclable epoxies, so you can't keep the carbon fiber or fiberglass but at least the epoxy is reusable and biodegradable. Those companies give us the possibility to make the world's "First Recyclable Composite Fishing Rod Launched" [5].

Additionally, a lot of research is made about the bamboo fiber, we propose the best solution is to mix the two previous hypotheses. This results in a fishing rod made of bamboo fiber with biodegradable epoxy, which is much better for the environment. We can also increase the flexibility and the toughness of the bamboo in composite materials. It's also less brittle than pure bamboo. Those hypotheses are too recent to be found on LCA and Granta edupack, that is why we can not see it on table 1.

4. EPDM Foam replacement

Originally, the handle of the fishing rod was made of an EPDM (ethylene propylene diene monomer) Foam. This synthetic rubber is made from ethylene, propylene, and a diene comonomer, through a process called sulfur vulcanisation. EPDM rubbers have good resistance to water, UV damage, and heat. The range of service temperature is between -50 and 150°C [6].
However, EPDM wastes causes environmental pollution with a large CO_2 footprint. As we calculated on the Granta LCA, the foam contributes to 2.4% of the CO_2 emission of the total product and needs 1.6MJ of energy (3.4% of the total energy needed). Even though Fthis is relatively low, this part is easy to change and make it repairable.

Thus, we chose to use cork instead of this EPDM/EPM material. Thanks to its low density, good elasticity and impermeability [7], cork is a suitable material for our handle. To avoid glueing the handle directly to the rod like the original, we thought about making the cork

handle with a screw system at the bottom of the rod to make it removable and reparable. This will enable the fisher to change the handle if one breaks or is too worn, instead of wasting the whole fishing rod.
Regarding the CO2 emission of cork, for the same mass of EPDM foam, it contributes to only 0.5% of the total CO2 emission and uses 0.08MJ, which is much lower than the EPDM. When harvested sustainably, the cork tree can live up to 200 years and be harvested every 9 to 12 years. [8]

5. Metal in the fishing reel and the rings

Although materials such as stainless steel and aluminium might be really energy/co2 intensive to produce, it is shown on the LCA diagram that these materials are long lasting and might be repairable or recyclable.
Indeed, stainless steel is one of the best recyclable metals, it is a champion!

Currently, already “60% of all new stainless steel comes from recycled material” and “90% of end-of-life stainless steel being collected and recycled into new stainless steel – without loss of quality.” [9] Stainless steel is a mix between iron and other alloys such as Chromium or Nickel which give it a special property to not be oxidized in the presence of water. In a metal recycling plant, first the different metals are separated and then it is possible to extract the stainless metal to use it as a raw material [10].

Figure 3: 2015 stainless steels end-of-life recycling rate [9]

Aluminum is also a very recyclable material, the hardest part is to separate the pure aluminum from the alloyed to reform it. With new technology, it is easier and we can find some plants specialized in recycling. [11]
Just like stainless steel, the aluminum can be endlessly regenerated without loss of capacity. [12]

So even if, one of the most impacting materials in our fishing rod is the stainless steel and aluminum which we have found not only in the reel but also in the rings used as a line guide. As it is recycled, we can use recycled metal to reduce the impact on the environment.
Inside the ring, an aluminum-oxide is inserted in the stainless-steel guide frame.[13] We thought about changing the aluminium by polymer (PARA), but due to the poor material properties of the plastic, it might not be a good option thus we keep aluminium and stainless steel. As the process of metal recycling needs to smash the product in small pieces to separate them after , we think that it’s better to have just 2 metals to recycle which is much easier.

6. Use case and lifetime emissions

The use of the fishing rod itself does not consume any fuels nor release emissions. However, most recreational fishers do not live directly on a body of water therefore transportation of the rod is required. The Trout Unlimited blog [14] reported that urban residents drive between six and 140 kilometers to access trout fishing streams. For rural residents this number is likely lower but can vary greatly depending on what type of fishing is desired. If just 50 kilometers is driven in a Skoda Octavia 1.5L TSI (fuel economy of 5.7L/100km), 2.85L of fuel would be combusted, emitting 6 450g of CO_2. We estimate that a recreational user would use the rod approximately 15 times per year, resulting in an annual emission of 97 750g (97,75 kg) of CO_2. During the assumed life time of 20 years with our product the CO2 emissions of using our product would add up to approximately 1955 kg. Therefore the CO2 emissions caused by using the product would be about 650 times higher than the emissions caused by producing the fishing rod.

It is more difficult to estimate the emissions of a boat because the engines are not running during the entire fishing trip. Additionally, if the user owns a boat they may need to use a more powerful vehicle to tow said boat, which would greatly increase emissions. Moreover, boats have a greater impact on marine life than just emissions. David N. Nedohin and P. Elefsiniotis reported in their study of the Effects of Motor Boats on Water Quality in Shallow Lakes [15] that motor boats disturb the bottom of lakes less than 10 meters deep.The mixing depth (see Fig[15]) varies on size of engine. The phosphorus that is stored at the bottom of a lake is mixed into the rest of the water which makes it easier for algae to consume. This results in an algae bloom that can block sunlight and reduce oxygen in a lake.

HORSEPOWER	*MIXING DEPTH (m)*
10	1.8
28	3.0
50	4.6

Fig[15]: David N. Nedohin and P. Elefsiniotis, *Effective Mixing Depth by Engine Size* (1996). University of Manitoba, Department of Civil and Geological Engineering.

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