Project Report
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Screening Life Cycle of recycled glycol

A climate impact study of the recycling processes of used glycol

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Preface

This report includes a climate impact study of the recycling processes of used glycol and a comparison with virgin made glycol.

The report was compiled by Elisabeth Olsson at Swerea IVF in collaboration with Robert Wahren, Core Competence AB and Recyctec AB, who has delivered data regarding the production of the recycled glycol at Recyctec AB.
The report and conclusions are not intended for comparisons with competing products.

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Summary

This is a climate calculation of the recycling process of glycol at Recyctec AB. The study has been done in collaboration with Recyctec AB, in October 2018.

Climate impact per kg recycled glycol at Recyctec AB is about 0,4 kg of carbon dioxide equivalents (CO_2-eq). Mainly the recycling process has been studied. For the corresponding virgin glycol, the climate impact is four to ten times larger. Thus, 1,5 to 4 kg of CO_2-eq per kg of glycol is saved when using recycled glycol from Recyctec compared with virgin glycol.

As a comparison measure for these figures, 1 kg CO_2-eq is in the same size as the climate impact of 50 grams of beef or about 10 kilometers of driving a modern petrol car.

Method

Simplified life cycle analysis has been used, which in principle means that only data on the amounts of materials and the recycling process are specific. Remaining data is generic, ie, they have been retrieved from existing LCA databases and generally represent global or European averages. In particular, data has been taken from Swerea IVF's own database and the commercial database Ecoinvent 3. For the calculations, SimaPro 8.5.0.0 was used.

Functional unit

As a functional unit, 1 kg of recycled glycol is used, meaning that all figures for resource consumption, emissions and environmental impact relate to manufacturing, cradle-to-gate, of 1 kg recycled glycol.

System boundaries

System boundaries (dashed line) for the study are shown in the figure below.

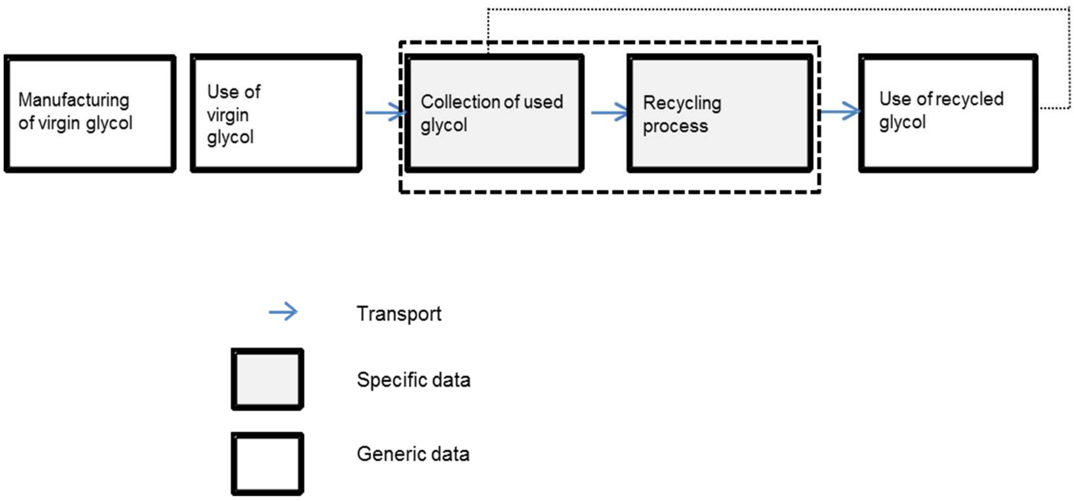

Figure 1 Scope of the study (dotted line)

Product specifications

Used ethylene- and propylene glycol are collected from different local areas in southern Sweden and transported to Recyctec AB in Jönköping, where it undergoes processes to be reusable again. Ethylene- and propylene glycol cannot be mixed from the collection local, they need to be separated for the efficiency in the recycling processes, however they go through the same processes and same conditions with the same yield.

Recycled glycol

The process includes several purification steps and a vacuum evaporation, where water, chemicals and energy are used. For each process step, all items which will have an importance for the climate impact has been taken into consideration. The process and process axillaries are modelled as in Table 1 below.

In this official version of the report, Table 1 has been omitted due to competitive reasons. We are not ready to disclose the details of every step in our process.

Assessment of environmental impact

In this study the result is reported as climate impact or greenhouse effect. Other categories relevant and commonly used, are acidification, ground-level ozone, eutrophication and abiotic depletion, see Appendix 1.

Results

The figure below shows the result for 1 kg of recycled glycol (ethylene glycol or propylene glycol). Climate impact is about 0,4 kg CO_2-eq per kg liquid glycol.

The thickness of the arrows corresponds to the greenhouse effect (climate impact) measured in carbon dioxide equivalents from the respective processes.

The figure shows that activated carbon, has a high impact.

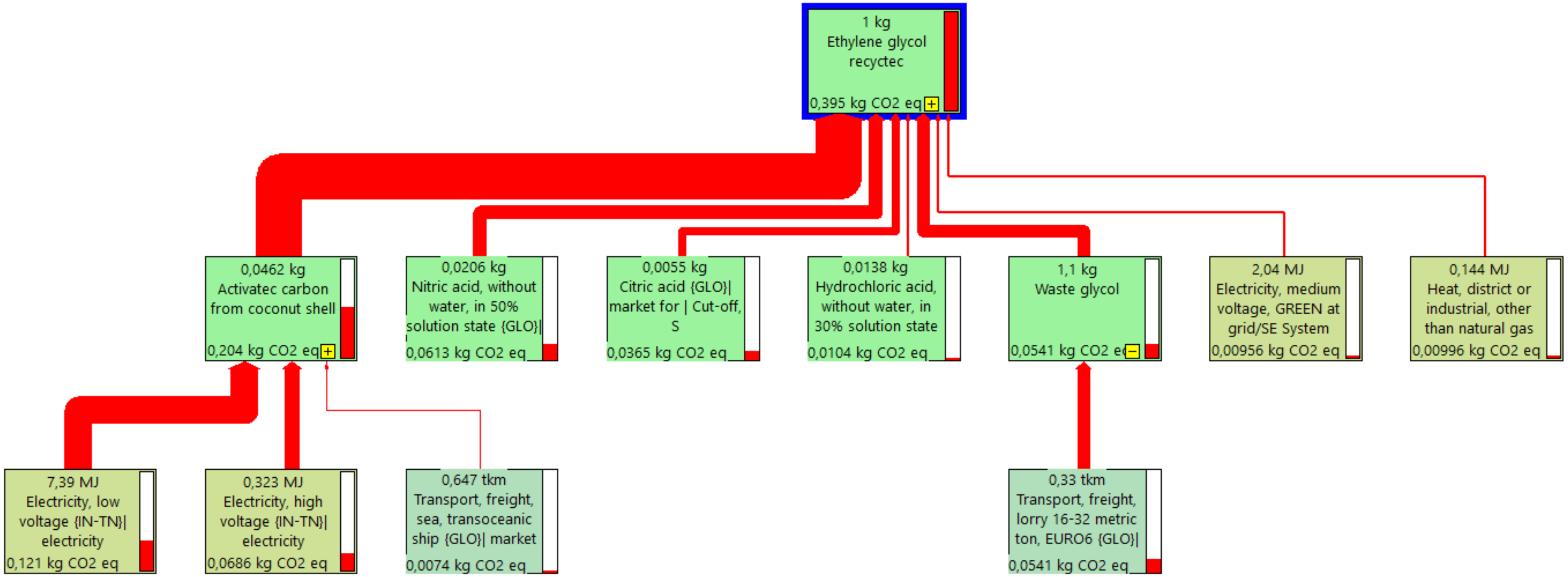

Figure 2 Climate impact (kg CO_2-eq) of recycled glycol

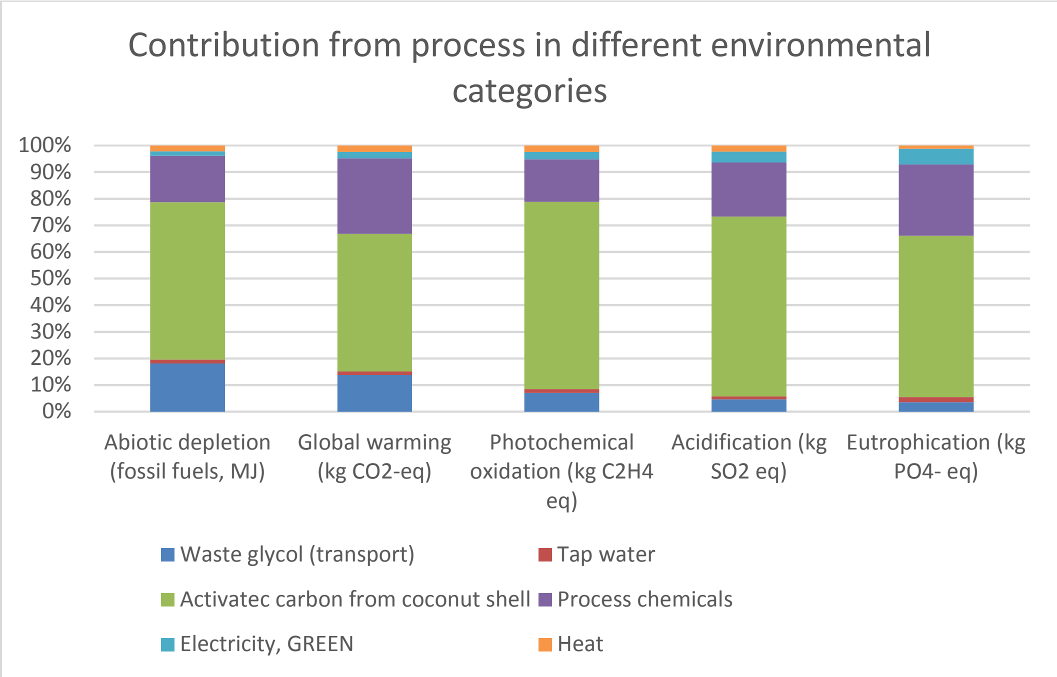

Figure 3 The distribution of the process resources in the impact categories; abiotic depletion photochemical oxidation acidification and eutrophication

In other environmental impact categories, the distribution from the recycling process is almost the same – the activated carbon has the highest impact in all categories

If recycling was to be made for example, in Germany, the recycling process would have a climate impact of almost the double compared to Recyctec. This due to that the average energy production in Germany has a higher climate impact.

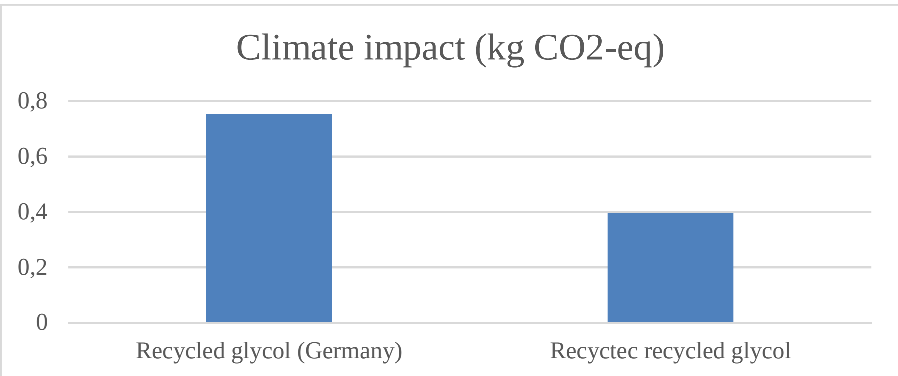

Figure 4. Example of climate impact when using Recyctecs processes but other energy production source.

Comparison with virgin glycol

Production of propylene glycol from propylene oxide and water with a process yield of 95% has, in Europe, an average impact of 4,5 CO_2-eq per kilo liquid glycol (generic data from Eco Invent data base). The processes included are raw materials and chemicals used for production, transport of materials to manufacturing plant, estimated emissions to air and water from production estimation of energy demand and infrastructure of the plant (approximation).

Production of ethylene glycol from oxidation of ethylene oxide leads to the production of 1 kg of three coproducts: ethylene glycol, diethylene glycol (DEG) and triethylene glycol (TEG) and has in Europe, an average impact of 1,8 CO_2-eq per kilo liquid glycol (generic data from Eco Invent data base). Raw materials, energy consumption and emissions are modelled with literature data. Infrastructure is included with a default value[1].

A comparison of virgin glycol (ethylene glycol and propylene glycol) and recycled glycol is shown in the figures below. As discussed previous, the climate impact is affected by how the electricity is produced why a virgin glycol production in Sweden might have lower climate impact than these European average values.

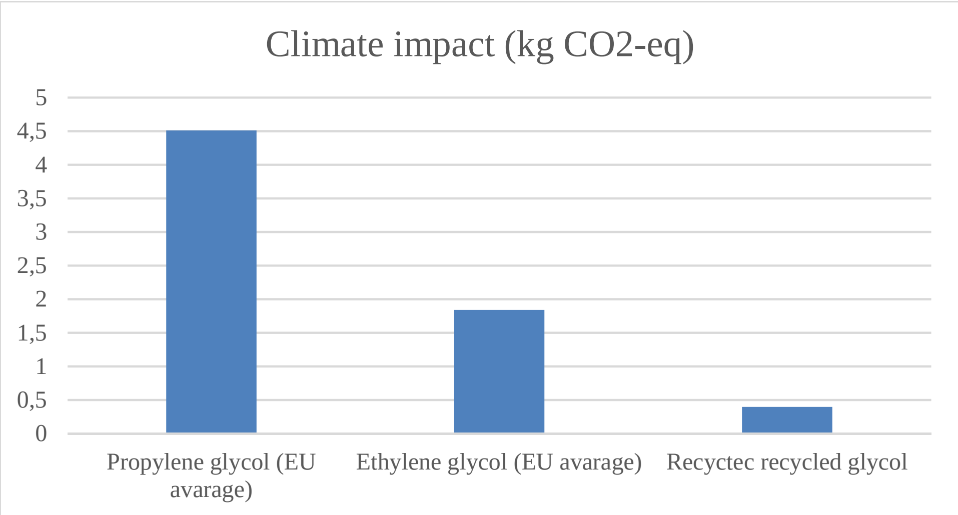

Figure 5 Comparing climate impact of virgin glycols and Recyctec recycled glycol.

[1] Information regarding the process (according to EcoInvent database;
Technology: Glycol products typically consist of 70 – 95% w/w of MEG, the primary co-product being DEG, some of which can further react to TEG. All of the EO feed is converted into MEG, DEG TEG as well as some heavy glycols, which may however be incinerated. 2 – 100 kg heavy glycols / ton EO can be produced.

With the above figure, recycled glycol from Recyctec AB saves approximately between 1,5 and 4 kg CO_2 eq compared with virgin glycol.

Discussion and conclusions

The focus in this study has been on the recycling process at Recyctec AB, the study does not cover any specific collection of glycols, nor the use phase. As seen in the calculations the assumed transport distance from collection of used glycols to Recyctec have some, not negligible impact.
The loss in the recycling process is approximately 10% and is included in the calculations. However, if ethylene glycol and propylene glycol are mixed in the incoming material flow, the yield will be lower with almost another 10%. This is not included in the calculations since the use of ethylene glycol and propylene glycol differ and mixes are rare.
The use of activated carbon in the recycling process has the largest climate impact, as measured here. The activated carbon comes from coconut shells, which is a residual product from the coconut oil production. Even though it is a biologic left over from the main production of coconut it undergoes energy demanding processes to become activated carbon and therefore contribute with a significant climate impact compared to the other auxiliaries.

Virgin glycol impacts between 1,8 and 4,5 kg CO_2 eq, while the climate impact of recycled glycol is less than 0,4 CO_2 eq.

References

General Programme instructions for an international EPD® system for environmental product declarations and Supporting annexes. Version 1.0 dated 2008-02-29.

ISO 14044. Environmental management – Life cycle assessment – Requirements and guidelines.

Appendix 1 - Environmental impact categories

Climate impact

Global warming, or climate impact, is measured as kilogram CO_2-equvivalents. Global warming is the gradual increase, over time, of the average temperature of earth's atmosphere and oceans sufficient to induce changes on the earth's climate. This increase on earth's temperature is related to the increase of the emission of gases, such as, CO_2, methane, water vapour, nitrous oxide and CFCs, among others, from anthropogenic (man-made) sources, mainly from the burn of fossil fuels. Europe´s emissions in 2005 corresponded to 11200 kg CO_2 equivalents per person[2]. Burning 1000 litres of petrol in a car generates approximately 2500 kg CO_2-eq as a comparison. To avoid unwanted global warming effects requires global yearly emissions to be reduced by between 50 to 85% by 2050 on current levels, according to the Intergovernmental Panel on Climate Change[3]. This would translate to approximately 1000 kg CO_2-eq per capita world average.

Acidification

The most important man-made emissions of acidifying gases are sulphur dioxide (SO_2) and nitrous oxide (NO_X) from combustion processes. Thus, acidification is measured in equivalents of sulphur dioxide SO_2. Acidification, or acid rain, is best known for the damage caused to forests and lakes. Less well known are the many ways acid rain damages freshwater and coastal ecosystems, soils and even ancient historical monuments, or the heavy metals these acids help release into groundwater. Europe's emissions in 2005 corresponded to 57 kg SO_2 equivalents per person[4].

Eutrophication

Eutrophication is measured as equivalents of PO_4. Nutrients like phosphor or nitrogen released in a lake leads to an increased production of planktonic algae. The algae sink to the bottom and are broken down with consumption of oxygen in the bottom layers, causing a dead environment at the bottom. The most significant sources of nutrient enrichment are the agricultural use of fertilizers, the emissions of oxides of nitrogen from energy production and wastewater from households and industry. In 1995 the Baltic Sea received 761 000 t nitrogen and 38 000 t

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[2] European Environment Agency, 2005. The European Environment, State and Outlook 2005. Copenhagen.

[3] IPCC, 2014. Climate Change 2014: Synthesis report. Contribution of working groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Summary for policymakers. Geneva, Switzerland.

[4] European Environment Agency, 2005. The European Environment, State and Outlook 2005. Copenhagen.

phosphorus from land[5]. The anthropogenic part of the nitrogen was assumed to be 79%, for phosphorus no assumption could be made.

Photochemical oxidation

Potential photochemical oxidation, or summer smog, is measured in kg ethene equivalents (C_2H_4).
Increased levels of ozone at ground level, arise through the reaction of volatile organic compounds, for example ethene and solvents, with oxygen compounds or oxides of nitrogen in air and under the influence of sunlight, so called photochemical oxidation. The effects on human health are amongst others irritation of eyes and mucous membranes as well as impaired respiratory function. Ground level ozone also has severe effects on vegetation, resulting in agricultural production losses.
Europe´s emissions in 2005 corresponded to 12 kg ethene equivalents per person[6]. Burning 1000 litres of petrol in a modern car generates around 1 kg ethene equivalents as a comparison.

Abiotic depletion (use of resources)

The environmental impact category for use of resources that is used here is abiotic depletion, which is taken from CML baseline (Guinee et al., 2001) and is measured in kg antimony equivalents (kg Sb-eq) or joule (MJ). The category includes two parts, abiotic depletion of elements and reserves and abiotic depletion of fossil fuels. The first part relates to the extraction of minerals and is based on the amount of reserves of each element that exists. When it comes to the abiotic depletion of fossil fuel, the influencing factors are based on the lower thermal value of the fuel.

[5] European Environment Agency, 2010. The European Environment, State and Outlook 2010: synthesis. Copenhagen.
[6] European Environment Agency, 2005. The European environment — State and outlook 2005.

Copenhagen