Quantification of Variability in the Life Cycle Greenhouse Gas Footprint of Laundry in Europe

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Objective

The variability in emissions occurring during the life cycle of laundry products related to consumer behaviour is often not fully quantified. Excluding variability from the analysis leads to an oversimplification of real life situations. In this study we have assessed the variability in greenhouse gas (GHG) emissions of laundry across 23 European countries using consumer habits data on product dosage and format, wash temperature and machine energy usage.

Methods

Functional unit: One washing cycle

Product categories considered: Powder, Liquid, Capsule and Tablet laundry detergents

Temperature categories considered: <30°C, 40°C, 50°C and >60°C

Resolution: 23 European countries

Technique: Monte Carlo simulation

Scope of the study:

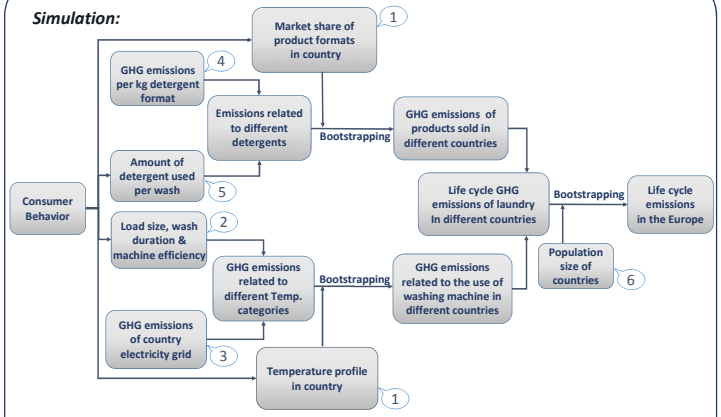
☑ Manufacturing of ingredients, manufacturing of detergents, packaging, transportation and the use phase were included in the analysis.

☒ Disposal of products as well as manufacturing of washing machines were excluded from the study.

Main Data Sources:

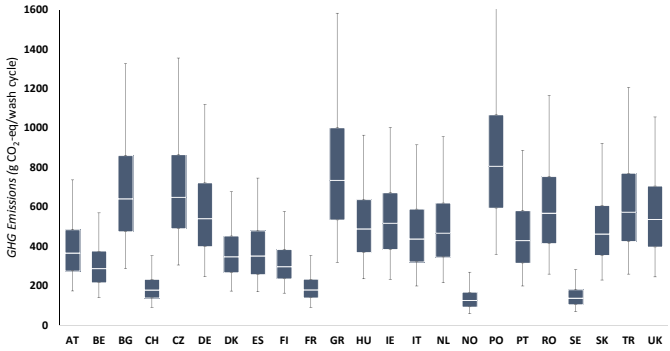
1. To model the differences in purchasing (detergent format choice) and consumer behaviour (temperature setting), we used the latest report of washing habits conducted by the International Association for Soaps, Detergents and Maintenance Products (AISE 2014). This report is based on a survey gathering information from consumers of 23 European countries (200 from each country).
2. The variability in the energy consumption of washing machines for a specific temperature setting was quantified using data from a field investigation exploring laundry habits over 100 UK households. The study, conducted in 2014 by Unilever, involved simultaneous collection of technical wash data using an advanced logger technology to record real wash information on e.g. duration, energy use and temperature setting.
3. We used the ecoinvent database v3.2 (Wernet et al. 2016) to include country-specific estimates of the GHG footprint of electricity consumption in our calculations.
4. Datasets developed within Unilever for annual carbon footprint reporting were used to estimate the variability in GHG emissions per amount of detergent for each product format.
5. We used the study by Kruschwitz et al. (2014) that quantified consumer variability in product dosing of powder, liquid and tablet detergents in Germany. For the dosing of capsule detergents, we assumed that consumers use one capsule per wash cycle combined with the range in the reported detergent volume per capsule provided by Unilever.
6. We used the World Bank online database for population sizes of countries.

Simulation:



Simulation procedure applied in this study. The numbers inside oval callouts refer to the data sources used for the input parameters of the model.

Results



Country-specific variability in the life cycle GHG emissions of laundry on a per wash basis (box plots show 5th, 25th, 50th, 75th and 95th percentiles) (AT: Austria, BE: Belgium, BG: Bulgaria, CH: Switzerland, CZ: Czech Republic, DE: Germany, DK: Denmark, ES: Spain, FI: Finland, FR: France, GR: Greece, HU: Hungary, IE: Ireland, IT: Italy, NL: Netherlands, NO: Norway, PO: Poland, PT: Portugal, RO: Romania, SE: Sweden, SK: Slovakia, TR: Turkey, UK: United Kingdom)

- GHG emissions per wash vary by a factor of **6.4** between the different European countries (calculated as the highest median value divided by the lowest median value). Norway has the lowest GHG emissions with **125** g CO_2-eq/wash cycle and Poland has the highest emissions with **795** g CO_2-eq/wash cycle.
- Within-country variability ranges between 3.6 and 5.0 in the European countries (90% interval).
- Taking the population size of countries into account, the median life cycle GHG emissions in the Europe are equal to **452** g CO_2-eq/wash cycle.

Results Continued

Sensitivity Analysis:

Contribution to variance of the variable parameters per country (in percentage). For each country, the darkness of the colour of each cell shows the importance of the cell.

Country	Detergent Type	Amount of product used per wash cycle	Load size, wash duration & machine efficiency	Temperature setting
Austria	6	8	32	54
Belgium	7	10	24	57
Bulgaria	1	2	37	60
Switzerland	21	33	19	27
Czech Republic	1	2	45	52
Germany	2	3	35	60
Denmark	5	9	39	48
Spain	4	6	35	56
Finland	7	13	49	30
France	26	28	14	32
Greece	1	1	34	64
Hungary	2	3	43	51
Ireland	2	2	40	55
Italy	4	4	25	68
Netherlands	3	4	33	61
Norway	31	58	6	6
Poland	1	1	41	58
Portugal	3	4	30	63
Romania	1	2	33	64
Sweden	25	56	10	9
Slovakia	3	4	45	49
Turkey	2	3	32	63
United Kingdom	2	2	39	57

- The life cycle GHG emissions are for the majority of European countries most sensitive to the **use of washing machines**.
- In countries with low-carbon electricity generation mixes, GHG emissions are most sensitive to the **type and amount of detergent used**.

Uncertainties:

- We assumed the energy consumption of washing machines in all European countries under study to be similar to that of the UK machines surveyed.
- For liquids, powder and tablets, we assumed the dosing behaviour in Europe to be similar to that of Germany. For capsules, we assumed consumers use only one capsule per wash.
- We assumed the GHG emissions from detergent production in Europe to be similar to the ones calculated in the Unilever annual footprint reporting and did not account for variability in the carbon footprints of single ingredients.

Conclusions & Recommendations

- A significant variability is observed between the life cycle GHG emissions from laundry in the different European countries under study. This variability is mainly due to the differences in electricity generation systems and to the behavioural variability in the use of washing machines.
- Further behaviour studies are needed to be able to develop more reliable models for quantifying the variability in the life cycle GHG footprint of household activities.

References

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