Global household methane inequality

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Combating climate change and reducing inequalities are among the worldâ€™s overriding goals in this century (SDG10 and SDG 13), and are closely interacting. Reducing inequalities in an emission-constraint world requires an in-depth understanding of Greenhouse Gas (GHG) footprints from different groups of populations worldwide.
Previous research has extensively explored carbon dioxide (CO2) inequalities of different households between and within countries. However, knowledge of methane (CH4) inequalities remains quite limited so far. On the one hand, CH4 possesses a strong global warming potential (GWP), which is more than 80 times greater than CO2, over its shorter lifespan. Therefore, targeting CH4 inequality reduction, lifestyle changes may curb the contemporary temperature rise more efficiently and effectively. On the other hand, CH4 emissions primarily stem from the production and transportation of oil, natural gas, coal, and agricultural activities, which is different from CO2 emissions that are dominated by energy combustion and manufacturing. This implies that previous conclusions from GHG (dominated by CO2) may not apply to CH4. Recently, several studies discussed the CH4 footprints of different countries and disparities within a single country. However, less is known about household-level CH4 inequalities at the global scale. In this context, this paper addresses the following question: What are the inequalities in CH4 footprints among various income groups in different countries and globally?
For the above purposes, we estimate the CH4 footprint of different household expenditure groups, by capturing consumption patterns across groups and countries at a high level of detail and linking it to our newly developed global environmentally extended multi-regional input-output (MRIO) model EMERGING (full-scale, near real-time multi-regional input-output table for the global emerging economies). The expenditure data in unprecedented detail is based and further adapted from the World Bank Consumption Dataset (WBCD), which distinguishes the consumption of 23,316 population groups (i.e., 201 expenditure groups in 116 countries, covering 87% of the global population). We obtain the CH4 emission data from EDGAR (Emissions Database for Global Atmospheric Research). By combining the fine-grained consumption data and the latest full-scale MRIO model, this study evaluates all economies (particularly emerging ones) based on country-specific data rather than introducing additional assumptions to split emerging countries from the corresponding region. Therefore, the emission inequalities quantified here are more comprehensive, detailed, and accurate than in previous attempts.
Our results indicate significant inequalities in global CH4 inequalities from households. In 2019, the top 1% expenditure bin induces 8% of the worldwide household CH4 emissions, equivalent to the total emissions caused by the bottom quarter. The per capita household CH4 of the richest 1% (277 kt) is more than 80 times higher than that of the poorest 1% (4 kt). The overall Gini index for CH4 inequality is 0.47, which is 33% higher than the average Gini income index in the same year, as reported by the World Bank. Supply-chain emissions induced by purchasing motor vehicles hold the highest inequalities among all types of household expenditures. The top 1% expenditure group is responsible for 24% of household emissions related to motor vehicle production, while the bottom 1% contributes only 0.02%. As a necessity, food consumption shows the lowest level of household CH4 inequalities among all expenditures, yet its Gini coefficient is still as high as 0.42. Notably, the key consumption categories we identified here differ from those in previous CO2 studies. For example, CH4 inequalities of transportation consumption rank top 3 among all expenditures, whereas it is among the bottom 3 expenditures in terms of carbon inequalities.
We further introduce the Theil index and decomposition approach to distinguish CH4 inequalities between and within countries. Our results show that variance in CH4 across expenditure groups

(i.e., within-country inequalities) is greater than between countries, contributing over 62% of the overall CH4 inequalities. The major contributor to CH4 inequalities starkly contrasts with CO2, where the between-country inequalities play a dominant role due to the influence of different energy mixes in different countries. At the national level, within-country CH4 inequalities generally increase with a countryâ€™s development. On average, CH4 inequalities in high- and upper-middle-income countries are threefold to those in low- and lower-middle-income countries. Each high-, upper-middle-, lower-middle-, and low-income country is, on average, responsible for 0.7%, 0.8%, 0.2%, and 0.3% of the total CH4 inequalities. Our findings may provide insights into ongoing debates on efficient and fair climate policies.