Regulating household physical carbon unlocks opportunities for significant and more equitable decarbonization in China: critical insights from multi-regional input-output model for carbon metabolism

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A significant amount of carbon is temporarily stored in products consumed by urban and rural households, contributing to climate change when released as gaseous emissions through incineration or landfill disposal. Despite the studies of accounting for trade-related physical carbon in product storage, long-term committed GHG emissions from household non-fossil-fuel products remain unexplored. This gap hinders informed and adaptive decisions on optimizing resource efficiency and product end-of-life management to meet the tightening carbon budgets. To address this research gap, we develop a technical framework for quantifying the cross-regional flows of physical carbon and committed greenhouse gas (GHG) emissions based on the multi-regional input-output (MRIO) model. We construct a production-based Physical Carbon Flow Dataset (PCD) that encompasses carbon embedded in five categories of products, including four non-fossil-fuel product categories and fossil fuels, at the provincial level in China, serving as a satellite account for consumption-based physical carbon metabolic modelling. Using this new approach, we track the physical carbon footprint (PCF) of fossil and non-fossil-fuel products driven by consumption in 30 provincial regions of China, quantifying the committed greenhouse gas (GHG) emissions from product end-of-life disposal from 2012 to 2060. Our findings reveal that non-fossil-fuel products accounted for nearly half of Chinaâ€™s PCF (406 Mt C) in 2020. Petroleum-derived products and crops collectively contribute 63% to the total non-fossil-fuel committed GHG emissions. Implementing efficient solid waste sorting and landfill gas utilization technologies nationwide could reduce GHG emissions by 75%-86% compared to baseline scenario by 2060 while potentially alleviating interregional carbon inequality. Through linking the carbon metabolic processes with productsâ€™ life cycles, we develop a system-based approach to quantify the physical carbon in products consumed or temporarily stored in households, as well as the emissions that may result at the end of their service time for the first time.