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Climate change and class structure: greenhouse gas emissions of social classes in the United Kingdom

Michael Lindner[a,b*], Robert Dorschel[c] and Antonia Schuster[b,d]

[a]*Department of Digital Transformation in Energy Systems, Institute of Energy Technology, Technische Universität Berlin, Berlin, Germany;* [b]*Potsdam Institute for Climate Impact Research (PIK), Member of the Leibniz Association, Potsdam, Germany;* [c]*Department of Sociology, University of Cambridge, Cambridge, UK;* [d]*Faculty of Life Sciences, Humboldt University of Berlin, Berlin, Germany*

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This interdisciplinary research article is situated at the interface of environmental studies and sociology. By bringing an ecological analysis of greenhouse gas (GHG) emissions to bear on contemporary class theory, we provide a new framework to analyze the social underpinnings of climate change. Our work offers the first operationalization of Andreas Reckwitz's theory of a fourfold class structure in post-industrial societies for the quantitative analysis of GHG footprints. Engaging with Reckwitz's diagnosis of a split middle class, we find no major division in terms of per capita GHG emissions within the middle layers. While the 'new middle class' exhibits slightly higher emissions than the 'old middle class', despite cultivating more pronounced pro-environmental values, the two middle classes are mainly differentiated through compositional factors. Based on representative expenditure data for UK households, we reveal that the old middle class has comparatively high housing-related emissions, while the new middle class creates substantially more environmental pressure through their mobility. At the same time, our analysis uncovers major disparities in terms of total emissions elsewhere in the class matrix. We demonstrate that the lower class has the smallest carbon footprint, while the upper class plays in an ecological (and not merely economic) league of its own. We discuss how these findings provide new insights into contemporary class relations and contribute to a better interdisciplinary understanding of the nexus between GHG emissions and power structures.

Keywords: greenhouse gas emissions; social class; inequality; Reckwitz; UK living costs and food survey

1. Introduction

The nexus between social inequalities and greenhouse gas (GHG) emissions has been a topic of manifold discussions (Ivanova and Wood 2020; Staab 2022; Wan et al. 2022). The analysis of education and income, for instance, has contributed to an understanding

*Corresponding author. Email:m.lindner@tu-berlin.de, Department of Digital Transformation in Energy Systems, Institute of Energy Technology, Technische Universität Berlin, Fakultät III, Einsteinufer 25 (TA 8), Berlin 10587, Germany; Potsdam Institute for Climate Impact Research (PIK), Member of the Leibniz Association, P.O. Box 6012 03, Potsdam 14412, Germany

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of varying GHG emissions patterns. However, what is often missing in discussions of the relation between social inequalities and GHG emissions is an account of their embeddedness in the class structure. From the perspective of class theory, economic and educational inequalities are manifestations of a relational system of conflictive groups (Bourdieu 1984). Environmental research often operates without a social theory of how inequalities are embedded in such a social formation. To address this deficit, this article pursues innovative interdisciplinary research at the crossroads of sociological theory and ecological research. It makes both theoretical and empirical contributions to the discussion on household GHG emissions and class affiliation.

Of the many theories of class society, Andreas Reckwitz's framework (2020; 2021a; 2021b) provides a compact heuristic for advancing the debate between sociology and ecological research. Drawing on Reckwitz's conceptualization of class structure in 'late modernity', we can differentiate four social classes: the highly precarious lower class which has to get by in a world stacked against those with low economic and cultural capital, the old middle class whose rootedness and traditional values are increasingly under pressure, the new middle class which thrives on the basis of their mobility and cultural capital, and the upper-class, a slim layer that is increasingly pulling away economically from the middle classes (Reckwitz 2021b). According to Reckwitz, this relational constellation, which is driven by the effects of the societal post-industrialization since the 1980s, is at the heart of the central conflicts and apparent growing polarization of Western societies. In particular, the split between the old middle class and the new middle class is put forward by Reckwitz as the constitutive factor behind political divides, which have been similarly understood as conflicts between between 'cosmopolitans' and 'communitarians' (Koopmans and Zürn 2019). Combining an analysis of GHG emissions with Reckwitz's class schema will allow us to explore environmental footprints in the context of a conflictive and dynamic relational web of both economic and cultural capitals, and to contribute critically to contemporary theories of inequality and polarization. This includes the literature that has challenged sweeping claims of Western societies being characterized by heightened degrees of polarization (Beck and Westheuser 2022; Kumkar and Schimank 2021; Mau et al. 2023; Mau 2021; Mau, Lux, and Gülzau 2020; Nachtwey 2021).

Focusing on the UK, we will explore GHG emissions across the class structure delineated by Reckwitz, based on a quantitative analysis of data from the UK Living Cost and Food survey (LCF) (Office for National Statistics, Department for Environment, Food and Rural Affairs 2021). We will combine the expenditure data recorded in the LCF with the national GHG emissions of the UK (University of Leeds 2021) to calculate private consumption GHG footprints for UK households. The empirical analysis is explorative in nature and calls for further studies that take into account a broader range of factors when operationalizing Reckwitz' framework. The main finding of our study is that the middle class is primarily divided through *compositional differences* in the form of domain-specific GHG emissions: the old middle class sustains comparatively high emissions linked to housing while the new middle class averages higher emissions related to mobility. In terms of overall emissions, the new middle-class totals slightly higher emissions than the old middle-class. Furthermore, we show that the upper class plays in a league of its own in terms of GHG emissions, while members of the lower class display the least GHG-intensive lifestyles (which are still, though, above individual emission thresholds that would be compatible with the ecological targets of the Paris Agreement).

In the next step, we will elaborate in more detail on our underlying theoretical framework and discuss relevant previous reserach. Secondly, we will delineate our methodology, which presents, to our best knowledge, the first operationalization of Reckwitz's

class theory for research on GHG emissions. The third part of this paper presents our exploratory empirical findings. Finally, we will discuss these findings with regard to their implications for class theory and the understanding of socio-ecological inequalities. In this context, we will also discuss how our focus on private consumption GHG emissions needs to be complemented with research on other sources of environmental pressures (Chancel 2022; Huber 2022). In the conclusion, we will comment on the design of social policies that aim to address environmental pressures by taking account of class dynamics, and point out avenues for future interdisciplinary research at the nexus of class structure and ecological impacts.

2. Ecological research and class theory

2.1. *Ecological inequalities*

Today's world is characterized by rising inequalities between individuals and social groups. Importantly, these inequalities are not only economic in nature but also exist in the form of differential contributions to climate change and different exposures to the consequences of environmental degradation (Chancel 2022). Countries or regions that industrialized early on and extensively relied on fossil fuels to meet their energy demands have disproportionately contributed to emissions in the past, and continue to do so today. National or regional ecological inequalities and the assessment of today's responsibilities for climate change thus require a historical lens. Despite contemporary efforts to decarbonize societies (Office for National Statistics (ONS) 2024), emissions from the UK and many other nations remain too high to achieve the jointly agreed climate goals, such as the Paris Agreement. According to the International Energy Agency (IEA), emissions were still rising about 1.1 % in 2023 (IEA2023 2024). When addressing the issue of *differential responsibility for climate change*, it is also key to recognize that certain socio-economic groups have a disproportionately high impact on the environment. A large body of work finds higher income (or expenditure) is associated with higher household CO_2 emission on the national level (Baiocchi, Minx, and Hubacek 2010; Büchs and Schnepf 2013; Girod and Haan 2010; Isaksen and Narbel 2017; Jacksohn et al. 2023; Roca and Serrano 2007; Steen-Olsen, Wood, and Hertwich 2016; Weber and Matthews 2008; Wiedenhofer et al. 2017; Zhang et al. 2017); the same applies for comparative studies (Ivanova and Wood 2020; Oswald, Owen, and Steinberger 2020). In 2019 the bottom 50% of the world's population was responsible for 12% of global carbon dioxide emissions, while the top 10% was responsible for 48% of total emissions (Chancel 2022). Furthermore, several multivariate studies consider the association of education and CO_2 emissions when other factors are controlled for (Baiocchi, Minx, and Hubacek 2010; Büchs and Schnepf 2013; Thumin and White 2008; Gough et al. 2011; Lenzen et al. 2006). Notably, with regard to education, a mixed picture emerges regarding the direction of the effect (Baiocchi, Minx, and Hubacek 2010; Carfagna et al. 2014; Inglesi-Lotz and Morales 2017; Lenzen et al. 2006). Importantly, scientific studies not only focus on socio-demographic characteristics, but also try to better capture the lifestyles and circumstances of emitters, such as considering time use and urban form (Wiedenhofer et al. 2018).

When researchers attend to the issue of class in their inquiries into the nexus of social and ecological inequalities, they tend to do so by focusing on the elite and their sky-rocketing emissions. The richest one percent of every country's population have been found to consume a combined amount of energy equivalent to meeting the basic needs of 1.7 billion people (Millward-Hopkins 2022). The elite stratum, also classified as the 'super-rich' (Otto et al. 2019) or 'mega-consumers' (Oswald et al. 2021), is considered to have

unparalleled access to resources and energy while wielding significant influence over politics, culture, and the economy on a global scale. Billionaires, especially from the US and western Europe, are expected to have carbon footprints that are thousands of times higher than those of average citizens (Barros and Wilk 2021).

What is largely missing in the existing literature, however, is a systematic analysis on how emissions are tied to the *class structure* of societies. While the emissions of the elite or the top 1%, 10% or 50% have been extensively studied (Chancel 2022), it remains underexplored what emission make-up emerges if we consider the more differentiated social structural relations delineated in contemporary class diagnoses. Schuster and Otto (2023) and Schuster, Lindner, and Otto (2023) have made initial attempts to operationalize sociometabolic classes, i.e. emission classes, and investigate their socio-economic implications. In this article, we propose to interrogate emissions in relation specifically to the class structure of Western, post-industrialized nation states. Drawing on the influential class theory of 'late-modern societies' developed by Andreas Reckwitz (2020; 2021b), we seek to provide a first step into linking the analysis of emissions with a four-fold economic-cultural theorization of class at the societal level. We believe that this will generate new insights into the nexus of social and environmental inequalities. In the following, we will elaborate on Reckwitz's theory and discuss how it can be used to map GHG emissions onto class relations and societal conflicts.

2.2. *Class theory and Reckwitz's account of late-modern socities*

Before elucidating on Reckwitz's diagnosis of the class structure of late-modern socities, it is necessary to step back and briefly recapitulate the class theoretical tradition more generally (naturally, we can only signal a few cornerstones due to limited space). The class theoretical tradition is heavily shaped by Marx' seminal work on how ownership over the means of production shapes the hierarchical differentiation of human societies. Rooted in this materialist tradition, an array of scholars sought to develop Marx theory into different directions. Eric Olin Wright, for instance, presented an account of a three-fold class structure. Adding to Marx' account of a binary division into those who own the means of production (the bourgeoisie) and those without such ownership (the proletariat), Wright developed an account of actors with a 'contradictory class location' (Wright 1976). This crucial intermediate layer, according to Wright, is made-up of professionals as well as small-scale entrepreneurs who cannot clearly be grouped into one side or the other (Marx originally predicted that this intermediate layer would diminish in significance). Apart from the Marxist school of thought, there also exists a Weberian class theoretical tradition in the social sciences which operates less via a relational framework where conflict and exploitation is inherent, and instead focuses more on unequal life chances in a number of domains and the role of the market (Goldthorpe 2010). One theorist who attempted to bridge the Marxist and Weberian lines of work is Pierre Bourdieu. In his work, Bourdieu developed a multi-dimensional account of class through analyzing the unequal distribution of multiple forms of capital (Bourdieu 1984). For Bourdieu, objective class positions are defined by three central forms of capital: economic, cultural, and social. More specifically: it is volume and composition of those three forms of capital that defines an actor's objective position. Furthermore, Bourdieu was also concerned with subjective class positions, defined through habitual schemas and lifestyles that are linked to an actor's objective class location. This latter, subjective dimension allowed Bourdieu to study in how far and in what ways actors with similar class positions 'on paper' transform into socio-cultural classes with shared interests and practices (Bourdieu 1985).

The Bourdieusian, multi-dimensional theorization of class broadly underpins the work of the sociologist Andreas Reckwitz (Reckwitz 2020, 2021b). The distinctive achievement of Andreas Reckwitz has been to provide a framework that addresses the contemporary social divides within a compact, but relatively encompassing theory of class structure. His work builds on and bundles an array of studies that diagnose an increasing level of economic inequality on the one hand (Milanovic 2016; Piketty 2014; Rosanvallon 2013), and cultural as well as political divides on the other hand (Hochschild 2018; Koopmans and Zürn 2019). For Reckwitz, the driving force behind these developments are the manifold effects of *post-industrialization*, which includes not only a shift to service and knowledge-based economies but also the expansion of university-based education. In the context of post-industrialization, Reckwitz argues, the relatively stable and homogeneous middle segment of industrial society has been replaced by two conflictive middle classes: a new middle class on the one hand and an old middle class on the other. These two classes are pitted against each other in-between a small but thriving upper class and a growing lower class of highly precarious individuals (Reckwitz 2021b, 45). The new middle class, which Reckwitz at times also refers to as the 'academic class' (Chatzoudis 2020), can be characterized as the rising middle bloc based on relatively affluent material conditions in combination with their distinctive cultural capital. Members of the new middle class are well-educated, creativity-oriented, spatially mobile (while preferring urban over rural habitats), and tend to work in the knowledge economy. Their conduct of life is shaped by a hybrid longing to combine career success with the experience and display of singularity (Reckwitz 2020, 207). The old-middle class, on the other hand, constitutes the middle bloc under pressure. Members of this class generally underwent vocational training and are rooted in the region they were born; they favor smaller cities and rural habitats over the metropolitan habitats of the new middle class, and can typically be found in traditional industry jobs, mid-level office and service occupations, or in independent crafts. Instead of singularity, mobility and creativity, the old middle class valorizes a 'social logic of the general' – of ordinariness, rootedness, and order (Reckwitz 2020, 202). In the context of the expansion of higher education, digitalization, and cultural shifts (Reckwitz 2021b, 41), however, this conduct of life is increasingly devalorized on economic and symbolic grounds, placing the old middle class in a subordinate position vis-à-vis the new middle class, which propels and profits from the structural transformations that go hand-in-hand with the deindustrialization of Western societies. Sensing these shifts and their loss of status, the old middle-class perceives the new middle class as 'unrooted selves', as subjects without a stable moral compass who have lost touch with the issues of normal people (Reckwitz 2021b, 54). The new middle class, on the other hand, considers the old middle class as one-dimensional, as lacking innovativeness, and as entangled with regressive political ideologies. Reckwitz's diagnosis of a split between new and old middle class thus allows observations of a divide between cosmopolitans and communitarians to be integrated within an overarching class model. Finally, the class framework can also be used to at least partially address ongoing shifts of voting behavior in terms of support for left- and right-wing parties (see already Achterberg and Houtman 2006).

Given the scope of its framework, Reckwitz's class theory has been highly influential (Burzan 2021). A lively reception has been especially pronounced in Germany and has increasingly been witnessed in other contexts (Axford 2021; Dorschel 2022a; Sorokin 2021). However, a critical discussion of his theoretical synthesis has also emerged (Beck and Westheuser 2022; Kumkar and Schimank 2021; Mau et al. 2023; Mau 2021; Mau, Lux, and Gülzau 2020; Nachtwey 2021). In our reading, the central critique of

Reckwitz's theory is that it overstates cultural and political conflicts while providing a too rigid account of class membership (with some scholars problematizing a lack of empirical data to back the theoretical claims). Most prominently, Mau, Lux and Westheuser have put forward a comprehensive study of opinions and values in Germany, demonstrating that in most arenas of society, consensus is bigger than portrayed by Reckwitz or by so-called polarization theorists, such as Koopmans and Zürn (2019), who take up a less class-centered perspective on social divides than Reckwitz. The elaborate critique by Mau, Lux and Westheuser (Mau et al. 2023) has contributed to a productive intellectual discussion of the complex nature of contemporary class society. Notably, though, the critique primarily rests on an evaluation of the conflict structure in Germany, a somewhat particular Western society due to its capacity, in previous decades, to retain a relatively robust industrial sector and corresponding workforce. More heavily post-industralized nation states such as the USA or the UK are typically not considered in rebukes to Reckwitz' class theory of the post-industrialized West. Furthermore, we believe it is worth noting that within the social sciences there exist only few alternative encompassing models of the class structure in Western societies that condense the complexity and nuances of social space to a comparable degree.[1] Our main issue with Reckwitz's class theory, and sociological class theories in general, is the absence of an empirically-grounded account of how emissions and environmental impacts play out across groups. Reckwitz argues that the new middle class – which encompasses predominantly 'cosmopolitans' and left-leaning voters – displays more concern for ecological issues and climate change than the old middle class, thus providing us with a cultural account of the symbolic and political positionings of these classes vis-à-vis ecological issues (Reckwitz 2021b, 55 and 66). However, it is unclear how the classes differ materially on ecological lines, e.g. in terms of GHG emissions, land-use or impacts on biodiversity. While Reckwitz's theory provides a multifaceted account of the economic and cultural polarization of contemporary Western society – a big picture that is often lacking in academic debates around the environment – the ecological dimension remains underexplored (Bröckling 2019). Focusing on GHG emissions, the following empirical analysis will allow us to reconsider societal class conflicts in the light of their material relation to climate change. Combining contemporary class theory with a systematic analysis of household GHG emissions computed from expenditure survey data will enable us to shed new light on the nexus of ecological impact and social inequalities.

3. Data and methods

3.1. *The UK living costs and food survey*

Our original data is drawn from the UK Living Costs and Food Survey (LCF) (Office for National Statistics, Department for Environment, Food and Rural Affairs 2021). This focus on the UK aligns with the terrain of Reckwitz's theory, which defines Western post-industrial economies as its scope: 'My analysis of contemporary society, moreover, is not restricted to Germany but, rather, pertains to the Western world as a whole' (Reckwitz 2021b, 6). While the UK is not representative of Europe, let alone the 'Western world' (Pohjolainen et al. 2021), we argue that the UK is an illustrative case for analyzing GHG emissions across the class structure of European countries given its advanced post-industrialized state. Due to the rapid de-industrialization commencing under the Thatcher government, the United Kingdom has been at the forefront of the shift towards knowledge- and service-based economies within the Global North. While its manufacturing industry has declined severely, tertiary sectors such as finance, digital tech, and

university-education have grown significantly since the 1980s (even though the university-education sector is increasingly under pressure).

The selected UK survey collects information on household expenditure for goods and services (Office for National Statistics, Department for Environment, Food and Rural Affairs 2021). Each household member is asked to complete an expenditure diary for a period of 14 days, which is then used to estimate their annual expenditure. Since some goods are bought very infrequently, additional questions refer to infrequent expenditures such as car purchases or annual fees, which are, in turn, scaled to yearly expenditure. The LCF is a representative household survey for the UK and records common socio-demographic variables, such as net household income and household size. We use expenditures for 406 different product categories available in the LCF sampling wave recorded from April 2018 to November 2019, with a sample size of 5473 households and 12,763 individuals.

3.2. *Calculating per capita greenhouse gas emissions*

To obtain per capita GHG emissions for every household, the LCF expenditures are converted to emission equivalents with the help of official statistics on the GHG footprint of the UK (University of Leeds 2021) for the year 2018. These statistics include the seven main greenhouse gases (given as CO_2 equivalents, here denoted simply as CO_2) and refer to 'consumption emissions' of goods and services used by UK residents, accounting for emissions arising along global supply chains as well as those generated directly through private motoring and burning fuel (University of Leeds 2021). Unlike the areal carbon footprint (ACF), we analyze personal carbon footprints (PCF) referring to all GHG emissions associated with an individual's consumption. The PCF takes into account the emissions from all the goods and services that an individual consumes (Heinonen et al. 2022). The total UK footprint would also include governmental consumption and capital formation however, but these are beyond the scope of a study focused on the private consumption of UK households. The total amount of emissions considered for the UK is 542.85 Mt, the survey is representative of a population of 65.11 million people, thus the average consumption footprint is 8.34 t. Disregarding the emissions of investments, which totaled around 90 Mt for the UK in 2018 implies that we are underestimating the contributions to climate change of wealthy and upper class households.

The UK GHG statistics disaggregate the private consumption GHG emissions of the UK into emissions for goods and services belonging to each of the 307 (sub-)classes defined in the 'Classification of Individual Consumption by Purpose' (COICOP) (Nations 2000). It includes classes such as food items, gas, electricity, motoring fuels, car purchases and air travel. To compute the GHG emission at the household level we need conversion factors, so-called GHG intensities, that specify the amount of GHG emitted for each £ spent. The first step in connecting the household expenditure data with the national GHG statistics is to determine the COICOP class of each product category in the LCF. Since there are more LCF codes than COICOP classes, sometimes multiple LCF codes are aggregated into the same COICOP class. Secondly, the national expenditure per COICOP class is computed as the sum of all LCF household expenditures in that class.[2] Dividing the total GHG emissions by the total expenditure, the GHG intensity for each COICOP class is determined. These conversion factors are multiplied with the spending of each household to arrive at the household-level emissions for consumption. Finally, the household emissions are divided by the household size to arrive at per capita emissions for each household. When averaging household variables we use the

weights supplied in the dataset, when average per capita emissions, we additionally take into account the household size to correct the household weights. Simliar approaches for computing emissions on the basis of household expenditures has been successfully applied in the literature (Baltruszewicz et al. 2023; Büchs and Schnepf 2013; Owen and Barrett 2020; Owen et al. 2017).

3.3. *Data preprocessing*

Alongside the household data, the LCF survey includes a questionnaire for the individuals in a household. The variable 'highest education per household', which is crucial for our operationalization of class, is aggregated from answers to these individual questionnaires. Unfortunately, 5116 out of 12,763 respondents did not provide information on their education, resulting in samples with missing data. Out of those, 2528 are currently in training (school or university) or are below school-age, leaving 2588 cases with missing education data (roughly 20% of samples).

For the missing samples, we took great care to retain all information in the data set and carried out a multiple imputation procedure with the *predictive mean matching* algorithm implemented in the R package `mice` (van Buuren and Groothuis-Oudshoorn 2011). The predictive model takes into account eleven socio-demographic variables that are commonly associated with educational attainment, such as gender and socio-economic status. To correctly account for the remaining uncertainty, the algorithm features a stochastic part and constructs six plausible imputations for every missing item. The four social classes delineated in Reckwitz's theory were assigned separately for each imputed data point. Mean values and standard errors reported in this article are aggregated across these multiple imputations, with the software `micombine` (Lumley 2019). Unless stated otherwise, the notion of *significant* difference implies a statistically significant difference between groups, using a standard 95% confidence level verified with a two-sided *t*-test.

3.4. *Operationalizing Reckwitz's class theory*

We operationalize Reckwitz's theory of class by considering income and education level, see Table 1. In other words, we use the economic and cultural resources available to households to determine their class status in the middle layers. Individuals with an academic degree who receive between 70% and 300% of the median income are defined as members of the new middle class; individuals without an academic degree who fall into this economic layer are considered members of the old middle class. While in quantitative research, the boundary between the middle and upper class is typically drawn at either 150% or 200% (Atkinson and Brandolini 2013; OEC 2019), we chose the income threshold for the upper class at 300% of the median income given Reckwitz's theorization of this class as a slim layer that is increasingly pulling away economically.

Table 1. Schematic view of the usage of the median equivalized income and the highest education in a household to operationalize Reckwitz' class theory.

	Median equivalized income	Highest education
Lower Class	$< 70\%$	Unspecified
Old Middle Class	$\geq 70\%$ and $< 300\%$	No academic degree
New Middle Class	$\geq 70\%$ and $< 300\%$	Academic degree
Upper Class	$\geq 300\%$	Unspecified

Given Reckwitz's understanding of class, our overall approach be considered a simplified operationalization since it leaves out norms, values and lifestyles more generally. Hence, we consider this article to be explorative in nature; our study is intended as a first step for merging quantitative socio-ecological research with Reckwitz' sociological class theory. At the same time, we wish to note that by taking economic and cultural resources into account in our operationalization, we do cover the two most important objective resources that Reckwitz identifies as determining class positions (Reckwitz 2021b, 48) (see Lux 2022 for a similar operationalization).

While an additional, direct incorporation of variables relating to values and norms would be desirable, these are often not recorded in surveys that provide other essential information for ecological research. In contrast, the variables of household income and highest education per household are widely available, and thus prospectively allow comparative studies of data recorded in different national or historical contexts. We use OECD equivalized income instead of household net income because it controls for household composition and size, and is thus more appropriate for measuring differences in wealth between households.[3] To arrive at an unambiguous mapping we use the highest education in the household, i.e. if at least one household member has an academic degree, a middle class household will be assigned to the new middle class. Thus we implicitly assume that the high cultural capital of one member has a substantial influence on the relative class position of the whole household.[4]

3.5. *Validation of the operationalization*

To conduct a rough validation of our operationalization empirically, we investigate in how far the class assignment carried out aligns with distinctions between the classes postulated by Reckwitz's theory. Aside from the differences with respect to cultural and economic capital, which are inherently captured by our operationalization, Reckwitz also predicts differences between the new middle class and the old middle class in terms of a rural-urban divide, a distinction between rootedness and mobility, and, crucially, in terms of norms and values.

The postulated divide between old and new middle class along the metropolitan-rural axis may be assessed by the share of households within each class living in London. While a more fine-grained location analysis was not possible due to the privacy policy of the data set, we find, in our sample, that members of the new middle class are almost twice as likely as members of the old middle class to live in the London metropolitan area, cf. Figure 1. To assess the 'rootedness' of households we study the time the household reference person[5] spent living at the current address, divided by their age (top coded at 80). The old middle class, we find, scores the most time in this regard, which correlates well with Reckwitz' analysis. While home ownership may also be interpreted as related to 'rootedness' and is higher in the new middle class than the old middle class, we understand it primarily as an indicator of wealth. Validation of the mobility distinction is implicit in the results detailed in the next Section 4.2.2. Reckwitz predicts an increased mobility of the new middle class, which should lead to higher mobility expenditures and thus a higher mobility GHG footprint. This is exactly what we find in the data. Finally, while no direct information on norms and values is given in the dataset, which constitutes a central limitation of our study, we assume that morals shape lifestyles and consumption decisions and may, in some cases and in a tentative manner, be indirectly assessed. Such cases arguably include meat consumption, a fiercely debated issue with regard to ecological impacts, which Reckwitz (2020, 227) predicts to be higher for the

	% in London	SEM	% no internet	SEM	% meat of total food	SEM	% lifetime spent at address	SEM
lower	10.69	±0.99	20.07	±1.11	19.64	±0.37	16.67	±0.51
old middle	8.25	±0.92	7.43	±0.76	21.59	±0.31	19.42	±0.5
new middle	16.00	±1.08	3.67	±0.54	18.52	±0.3	16.61	±0.44
upper	30.05	±4.95	0.74	±0.74	19.53	±1.5	16.18	±1.42

Figure 1. To validate our operationalization of Reckwitz' theory, we study for each class the fraction of households living in London, the fraction of households without internet access, as well as the share of meat in total food expenditure of the household and the time the household reference person spend at the current address divided by their age. The observed variables hint, that the households assigned by our operationalization to the old middle class follow are more traditional, meat-based diet, are less likely to live in the metropolis London, and spend longer periods of their lives at the same address.

old middle class since the new class more often cultivates a vegetarian lifestyle. Hence, we computed the share of meat products among total food expenditure and find that it is significantly higher for the old middle class and lower for the new middle class (see Figure 1. Similarly, households in the new 'digital' middle class, nearly all have internet access. The share of households without internet access is twice as high in the old middle class. However, just as home ownership, internet access is correlated with wealth and decreases from class to class. Thus, based on our data, it is not possible to say for sure if the observed deviations in internet access are due to norms and values, or to economic necessities.

To the best of our knowledge, we present the first study that attempts a quantitative operationalization of Reckwitz' class theory for ecological research. Thereby we try to fill a gap in the literature, because up to now Reckwitz' theory is purely deductive with little empirical substantiation. While we see some good agreements of our operationalization with Reckwitz theory, it also has substantial shortcomings and should only be seen as a first attempt. A more complete methodological operationalization of the theory should rely on more determinants and directly incorporate norms and value into the operationalization alongside cultural and economic capital. With our intention to obtain a first impression of how carbon emissions relate to classes in a post-industrial society such as the UK, our operationalization prioritizes exploration, conceptual clarity and straightforward applicability. The latter is achieved by only relying on income and education as input variables, which are widely available in different datasets and for different countries.

4. Results

4.1. *Characteristics of the four classes*

Figure 2 shows the distributions of academic degrees, equivalized income, home ownership and the average household size for the respective classes. Since education is positively correlated with income (FitzRoy and Nolan 2020), it is not surprising that the upper class has a high share of households with an academic degree (84.6%). On the other hand, as a consequence of our operationalization a relatively large subgroup of individuals which hold academic degrees is assigned to the lower class (27.3%). This is somewhat unexpected and warrants further investigation into the socio-economic position and emission patterns of this subgroup, particularly in comparison to the old and new middle

	% academic degree	SE	Equivalised Income	SE	% owning home	SE	Average Household Size	SE
lower	27.28	±1.8	9657	±88	43.48	±1.36	2.25	±0.04
old middle	0.00	±0	23848	±236	68.46	±1.31	2.27	±0.04
new middle	98.88	±0.3	28814	±270	78.17	±1.16	2.56	±0.04
upper	84.57	±3.63	85866	±2090	86.22	±3.92	2.31	±0.11

Figure 2. Estimated mean values and standard errors of the share of academic degrees, equivalized income, home ownership and average household size. The share of academic degrees in the new middle class is not exactly 1, since in some households all adults still attend university.

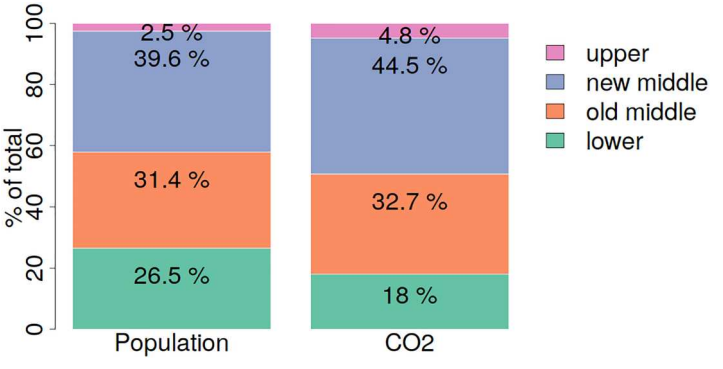


Figure 3. Relative distribution of population and CO_2 emissions for each social class.

classes, in a more detailed study. Regarding equivalized household income, the new middle class is slightly better off than the old middle class; and while the upper class is pulling away economically, the lower class is left behind. The new middle class may be said to be slightly more wealthy than the old middle class based on higher home ownership rates, which is another indicator of wealth.

Figure 3 shows the relative distribution of population and GHG emissions for each social class. While the lower class and the two middle classes have roughly the same size, the lower class emits proportionally less CO_2. At 2.5% of the total population, the upper class constitutes a thin layer which is not only increasingly pulling away economically (cf. Section 1), given that its emission share is almost twice its population share. While these differences in GHG emissions may be considered unjust, they are less striking than those for the global population, where the top 10% with respect to income cause 48% of CO_2 consumption emissions (Chancel 2022). In this regard it has to be noted that our analysis does not consider the GHG impact of investments, which would increase the share of emissions of the upper class. Similarly, the dataset does not sufficiently cover super-wealthy households, see the discussion of limitations in Section 5.3.

4.2. *Ecological dimensions of the social classes*

Our first key finding is that the new middle class has slightly larger total private consumption GHG emissions than the old middle class, cf. Figure 4. However, and this is our second key finding, this is not uniformly true for all sectors. Instead we find a

compositional differentiation of the GHG footprint in the middle layers. While the old middle class has comparatively high housing emissions, the new middle classes emits more due to their higher miscellaneous consumption and most importantly their increased mobility, see Sections 4.2.1–4.2.3. While the sector-specific differentiation of GHG emissions in the middle-layers of society is important, our study also shows how the upper class plays in its own league both economically and ecologically. While the emissions of the lower class are approximately 3t CO_2 lower than those of the middle classes, the emissions of the upper class are 6t greater than those immediately beneath it. Indeed, a typical upper-class household enjoys the combined GHG emissions of a lower-class and middle-class household. These differences are especially pronounced in the mobility and 'other consumption' sectors (which includes e.g. emissions due to food consumption and holidays), see Sections 4.2.2 and 4.2.3. It is important to note, that we find these increased emissions of the upper class even though our data does not include emissions due to investments, which may compromise a large share or even the majority of emissions for very wealthy households (Chancel 2022).

4.2.1. *The hidden cost of housing: the emissions gap between the old middle class and new middle class*

Housing-related GHG emissions in the context of our study are produced by electricity usage, heating with gas or other fuels, general maintenance, as well as other housing-related consumption such as water usage. Figure 5 provides a detailed overview of these emissions for households in each class. In terms of housing, the overall differences between classes are small in magnitude. This finding aligns well with existing research, which has found no strong correlation between household energy use on the one hand and education and income on the other(Büchs and Schnepf 2013; Owen and Barrett 2020; Schuster, Lindner, and Otto 2023). Consequentially, energy for housing has been understood as inelastic to income (Oswald, Owen, and Steinberger 2020). Interestingly, we find that the new middle class has a comparatively low housing footprint, which is probably related to their higher household size and the associated benefits of sharing heating and electricity, cf. Figure 2. The difference in mean emissions of the old and the new middle class is relatively small and only statistically significant at a lowered 90% confidence level.

4.2.2. *High mobility causes higher emissions in the new middle class*

Emissions in the mobility sector arise mainly from individual travel by car, public transport, or air, see Figure 6. Emissions arising from other means of transport, such

	Housing	SE	Mobility	SE	Other	SE	Total	SE
lower	2.35	±0.05	1.39	±0.07	1.91	±0.05	5.66	±0.11
old middle	2.58	±0.05	2.92	±0.12	3.19	±0.07	8.68	±0.16
new middle	2.46	±0.05	3.54	±0.14	3.40	±0.08	9.40	±0.19
upper	3.77	±0.29	5.90	±0.68	5.92	±0.39	15.59	±1.01

Figure 4. High-level overview of GHG emissions for each social class. The new middle class emits more than the old middle class in total and in the mobility and 'other consumption' sectors. Nevertheless the old middle has a comparatively high housing footprint.

	Electricity	SE	Gas	SE	Other Housing	SE	Total	SE
lower	0.60	±0.01	1.50	±0.04	0.25	±0.01	2.35	±0.05
old middle	0.62	±0.01	1.64	±0.04	0.32	±0.01	2.58	±0.05
new middle	0.58	±0.01	1.55	±0.04	0.33	±0.01	2.46	±0.05
upper	0.89	±0.09	2.35	±0.24	0.53	±0.07	3.77	±0.29

Figure 5. Average housing CO_2 emissions and estimated standard errors of the mean estimates (SE) for each social class. In the housing sector the old middle class has higher emissions than the new middle class.

motorcycles, are included in the totals but are not discussed in this section, since their overall contribution is small.

The mobility sector features the most pronounced differences in emissions with the upper class totaling almost four times the amount of CO_2 of the lower class. At 2.9 t and 3.5 t CO_2, the old middle class and new middle class more than double the mobility emissions of the lower class. While the old middle class and new middle class have similar car use emissions, the new middle class emits significantly more GHG by public transport and air travel. This finding aligns with the increased mobility of the new middle class postulated by Reckwitz. Thus, we find that the analyzed social classes correlate with distinct mobility patterns. A more detailed account of further socio-economic drivers and locked-in behaviors related to high car or air travel emissions is given by Mattioli, Büchs, and Scheiner (2023). An open research question is the extent to which the comparatively low emissions of the lower class in this sector are at least partly due to more efficient mobility patterns, or rather generally due to insufficient resources and access to mobility, i.e. 'mobility poverty' (Kuttler and Moraglio 2021).

4.2.3. *Varying emissions due to 'other consumption'*

The 'other consumption' sector subsumes all emissions not pertaining to housing (COICOP category 4) or mobility (COICOP category 7). It includes, among others, emissions arising from food, clothing, health, recreation, restaurants, and holidays.[6] Highlighted in Figure 7 are the contributions of food consumption, especially meat, and of expenses for restaurants and holidays.

While pronounced differences between the lower, middle, and upper classes are apparent, we find that the total emissions due to 'other consumption' differ only slightly between the old and the new middle class. However, as is the case for the overall GHG footprint (cf. Figure 4), micro-compositional differences related to lifestyles come into

	Cars	SE	Public	SE	Air	SE	Total	SE
lower	1.00	±0.04	0.11	±0.02	0.24	±0.04	1.39	±0.07
old middle	2.09	±0.06	0.12	±0.02	0.62	±0.08	2.92	±0.12
new middle	2.10	±0.06	0.44	±0.05	0.93	±0.12	3.54	±0.14
upper	2.90	±0.29	1.15	±0.38	1.68	±0.49	5.90	±0.68

Figure 6. Average mobility-related CO_2 emissions and estimated standard errors of the mean estimates (SE) for each social class. The new middle class has higher mobility emissions than the old middle class, due to greater usage of public transport and air travel.

	Meat*	SE	Other Food*	SE	Restaurants, Holidays*	SE	Miscellaneous	SE	Total	SE
lower	0.56	±0.01	0.28	±0	0.24	±0.01	0.83	±0.04	1.91	±0.05
old middle	0.79	±0.02	0.34	±0.01	0.50	±0.01	1.56	±0.07	3.19	±0.07
new middle	0.68	±0.02	0.34	±0	0.59	±0.02	1.78	±0.07	3.40	±0.08
upper	0.97	±0.09	0.45	±0.02	1.17	±0.09	3.33	±0.33	5.92	±0.39

Figure 7. Average CO_2 emissions due to 'other consumption' and estimated standard errors of the mean estimates (SE) for each social class. The color bars of the categories marked with (*) have been scaled by a factor of 2 for better visualization of small differences.

view when zooming in on sub-sectors. Exemplarily, the old middle class has significantly higher emissions due to meat consumption, while the new middle class emits more due to holidays and restaurants.

While food is a basic good, and as such relatively inelastic to income (Oswald, Owen, and Steinberger 2020), the upper class has a markedly higher GHG footprint due to restaurants, holidays and other 'miscellaneous' forms of consumption.

5. Discussion

5.1. *Ecological inequality and class conflict*

When economists and sociologists speak of Western societies as divided, they usually refer to economic and cultural inequalities to build their cases (Piketty 2014, 2021; Savage 2015). Furthermore, particular attention is currently devoted to the middle layers of society, which are commonly described as in a state of conflict, if not antagonistic decomposition (Hochschild 2018; Koopmans and Zürn 2019; Reckwitz 2021b). But what about the ecological dimension? How are GHG emissions distributed across distinct socio-economic groups? In our empirical analysis, we demonstrated that in terms of private consumption GHG emissions, there are only small differences between the old and new middle class. In other words: The two do not play in different leagues in terms of the total size of their GHG footprints. This finding suggests that while economic and cultural divisions appear to be pronounced (the degree to which is disputed), ecological impacts through personal consumption are more uniformly spread across the middle-classes. At the same time, though, our study reveals important *compositional differences* between the new and the old middle class in their contribution to climate change. While the new middle class has slightly higher emissions than its middle-layered counterpart in most sectors, its emissions are especially pronounced in the mobility sector and, on the other hand, are lower with regard to emissions arising from housing and certain other activities, such as meat consumption. Drawing on Bourdieu, these compositional differences can be theorized as *horizontal class differences* between the old and new middle classes as parts of a broader middle stratum. Following Bourdieusian class theory, social classes are no monolithic blocs but internally differentiated into fractions with different compositions and deployments of capitals (Bourdieu 1984). The compositional ecological differences must be understood as linked to distinct ecological middle-class fractions with their own spaces of possibilities.

Our finding of compositionally different but in sum relatively similar per capita GHG emissions across the middle-classes is also relevant for the discussion of eco-moral

boundary-makings. A number of studies have shown that higher levels of cultural capital go hand in hand with a more pronounced self-understanding as 'ecologically conscious' (Carfagna et al. 2014; Eversberg 2020; Halman et al. 2022). Furthermore, when members of the new middle class place and present their conduct of life favorably within a symbolic hierarchy of eco-friendly behavior, ecological consciousness can translate into ecological forms of distinction vis-à-vis the old middle class and lower class (Reckwitz 2021b, 66; Dorschel 2022b, 135; Neckel et al. 2018). Our study of emissions is able to demonstrate that distinctions by the new middle-class, at least as operationalized in our explorative research design, are performed on thin ice when taking total emissions into account. Bluntly put, the new middle-class can be considered to reap symbolic profits when presenting themselves as more ecological conscious than the old middle-class and especially so when drawing eco-moral boundaries vis-à-vis the lower class. At the same time, though, it is important to stress that the old middle-class is characterized by only slightly lower emissions than the new middle-class. Given this circumstance, our findings speaks to some of the arguments put forward by Mau, Lux and Westheuser (Mau et al. 2023) on the question of the degree of middle-class polarization. The trio has highlighted that the middle class is not as divided in terms of opinions and values as some claim (at least in Germany). Along different but related lines, our study highlights that the middle-class is not as ecologically divided in terms of total emissions as some would suspect. At the same time, our finding of compositional ecological differences can be considered to point to a possible undergirding source of 'trigger points', a concept with which Mau, Lux and Westheuser aim to analyze and explain recurring episodes of heated disputes and symbolic confrontations in a number of arenas of society. We contend that distinct emission profiles can function as an eco-material base to certain 'trigger points' in the sense that specific consumption practices by others become the object of intense scrutiny and ground for symbolic boundary-makings.

With regard to total emissions, it is also important to underscore that based on our findings, severe ecological divides, understood with respect to total GHG emissions, do exist if we zoom-out beyond the middle-layers. Our study reveals that the most significant divides in terms of GHG emissions lie not within the middle-class but elsewhere. While the upper class is pulling away economically, its GHG emissions also place it in a league of its own. The upper class's consumption patterns result in a much higher carbon footprint, even though our data does not even contain GHG emissions related to investments, which are especially large for the upper class, cf. Section 5.3. At the same time, the lower class has by far the lowest GHG emissions; their lifestyle is the most environmentally sustainable in terms of total emissions. Interestingly, members of the lower class have rarely seized upon the possibility to present themselves as ecological conscious – pro-ecological self-presentations have been primarily observed among members of the new middle class (Dorschel 2022b, 135; Neckel et al. 2018). At the same time, though, it must be acknowledged that none of the four classes analyzed in our study achieves a level of GHG emissions compatible with the goals of the Paris agreements, which calls for critical discussions concerning in how far ecologically sustainable conducts of life are realistically possible and socially sustainable in post-industrialized societies.

5.2. *Implications for class theory*

At a more general level, our study suggests a possible reorientation of the dominant sociological conceptualizations of class, which have so far operated without any account of GHG emissions. Ecology and climate change-related issues do find their way into theories

of class through subjective factors, e.g. ecological and climate consciousness and corresponding forms of distinction (Dorschel 2024; Huber 2022; Kennedy and Givens 2019). A very elaborate recent study of the nexus between ecological mentalities and class in Germany has been put forward by Eversberg et al. (2024). Objective ecological factors, like GHG, water or nitrogen footprints, or even a holistic mapping of environmental degradation caused by individuals, however, are generally not empirically established. One of the first approaches in this direction was the attempt to define and analyze socio-metabolic classes (Otto et al. 2020; Schuster, Lindner, and Otto 2023; Schuster and Otto 2023).

Our article now provides a first step towards linking ecological research with theoretical conceptualizations of the contemporary class structure. While Reckwitz's theory of the class structure of late-modern societies has proven very useful for contextualizing GHG emissions within a societal account of the group-based economic and cultural conflicts, it lacks a consideration of where actors are positioned with regard to the exploitation of natural resources. In the light of the Anthropocene (Lewis and Maslin 2015), though, we may widen common understandings of exploitation by considering GHG emissions as a direct exploitation of nature and an indirect exploitation of the socio-ecological living conditions of human beings. From this perspective, class positions should not only be defined through one's location in the industrial production process or the unequal distributional matrix of cultural capital but also through one's relationship with ecological resources.

Locating individuals in an ecological matrix is no easy task. It is important to underscore that our study of GHG emissions captures merely one aspect of an individual's relationship with ecological resources. Our study must thus be understood as an exploratory effort in working towards a more multi-dimensional class analysis that is attentive to ecological exploitation. Beyond GHG emissions through consumption, a holistic account of eco-social class will, for instance, require an analysis of individuals' locations in production-sector supply chains (Huber 2022). To provide an illustrative example: an industrial worker who labors for an oil drilling company has a different eco-social position (and corrsponding political interests) than an industrial worker who works for an offshore wind park company, even if they are responsible for exactly the same GHG emissions through their housing, mobility and other consumption. A holistic conceptualization of eco-social classes would therefore take into account both the individual carbon footprint through various forms of consumption, as well as the location within, or dependency on, the system of production. Such a conceptualization is necessary to avoid neglecting the larger structures within which individuals are embedded. A first study in this direction has recently been published by Pottier and Treut (2023).

5.3. *Empirical and methodological limitations*

Our operationalization of Reckwitz's theory is based on income and education. Due to data limitations, we were not able to consider personal values and norms, which are also decisive for determining social class according to Reckwitz, and which could form the basis of further research. Additionally, we are focusing on income and not wealth when constructing social classes. This can be considered a narrow focus on economic capital given the increasing relevance of wealth for class (re)production (Waitkus and Minkus 2021), which would be a productive avenue for future research. Furthermore, the data we draw on does not sufficiently cover high- or ultra-high-net-worth individuals, which are conspicuous for their extremely high CO_2 emissions (Otto et al. 2019). For

example, we do not consider the GHG emissions of investments, which may compromise a large share or even the majority of emissions for very wealthy households (Chancel 2022). Along these lines it should also be noted that due to anonymization in the dataset several variables are top-coded, e.g. age, number of rooms and income. Especially for the upper class this means that we are underestimating average income and to a lesser degree housing emissions as well.

There are some general limitations to estimating personal GHG footprints from consumption expenditure data, since they are not always equal to the estimated GHG intensity of the consumed goods. For example, this approach precludes drawing on data about renewable energy usage, which would imply lower GHG footprints for some households. Similarly, if the same good is sold at two different prices, the consumer who pays more will be assigned a higher GHG footprint, regardless of the actual emissions[7] Thus, the higher expenses of wealthy individuals do not necessarily translate to higher GHG emissions (Girod and Haan 2010), which raises the possibility that the GHG footprint of the middle or upper classes may be overestimated. However, including GHG emissions related to capital investments, would very likely more than exceed any overestimation due to price-distorted luxury goods. Finally, we would like to point out that the contribution to climate change of aviation is only partially caused by direct emission of long-lived GHG. Lee et al. (2021) estimate that non-GHG sources of short-term radiative forcing may approximately double the aviation impact – however, there still remains considerable uncertainty about their magnitude. As of now, such non-GHG climate forcings are not included in the official GHG emission reporting of the UK (University of Leeds 2021), on which our footprint estimates are based. We believe that future work should broaden the perspective of the ecological impacts of the different social classes – e.g. by considering non-GHG climate forcings, but also by quantifying impacts on other Planetary Boundaries (Rockström et al. 2009, 2021; Steffen et al. 2015), such as freshwater use and eco-sphere integrity.

6. Conclusion and outlook

This interdisciplinary study has brought an ecological analysis of GHG emissions into contact with contemporary class theory. Our study has analyzed and interpreted the compositional differences in GHG emissions for households against the backdrop of relationships between the lower, old-middle, new-middle, and upper classes. While it did not investigate the drivers of CO_2 emissions with multi-variate analysis, our study marks the first of its kind to operationalize the social classes described by Reckwitz in an effort to analyze their contributions to climate change. Our paper has demonstrated that emission profiles can be better understood in the context of a relational class structure, as opposed to a rudimentary income-level framework.

In the discussion, we have pointed to the empirical and theoretical implications of our explorative research. We consider the nexus of ecological impacts and social class to be highly relevant for institutional policy-making concerning ecological issues. Understanding compositional ecological differences is crucial for developing equitable and effective environmental policies that address not just the quantity but also the origins of emissions across different socio-economic strata. Awareness of the compositional differences in GHG emissions within the middle classes may help to design balanced policies, especially in the mobility and housing sectors. Otherwise, if one class perceives itself to be disproportionally affected by the cost of low carbon policies, cultural and political divides might be exacerbated. In other words: claims regarding the fairness of GHG reduction policies

need to differentiate between emission sectors such as housing, mobility, and consumption. Potential levers for a low-carbon transition in the housing sector, which, as we have seen, will particularly affect the old middle class, include retrofitting, and policies disincentivizing the overconsumption of floor space (zu Ermgassen et al. 2022), see also (Fink 2011; Ivanova and Büchs 2022). Transitioning from individual to public transport holds large potential to reduce the emissions of all classes. Similarly, switching (long-distance) mobility to the digital sphere where it is feasible, may provide a low-carbon alternative for highly mobile lifestyles (Lenz 2022). Another strategy to lower mobility emissions may be to promote more rooted conducts of life across the class matrix. Furthermore, more attention to the very high GHG emissions of the upper classes is called for – to the emissions related to consumption, as well as those related to investments. This might be particularly relevant for environmental movements which aim to win over larger segments of the class structure (Reichel, Plüschke-Altof, and Plaan 2022)

At the same time, it is important to come to terms with the ultimately unsustainable levels of GHG emissions across the class structure of the post-industrial societies. The concept 'remaining carbon budget' refers to the total amount of CO_2 emissions that can be emitted into the atmosphere while not exceeding a threshold of temperature increase over pre-industrial levels, and is typically calculated for temperature increases of between 1.5 and 2 degrees Celsius (Intergovernmental Panel on Climate Change (IPCC) 2021). According to latest estimates, the remaining global carbon budget for a 50 percent chance of limiting warming to 1.5°C is 200 $GtCO_2$ (Forster et al. 2024). Even more generously estimated carbon budgets only allow for equal per capita shares of approximately 2 tons of CO_2 per year (Chancel 2022; Lucas et al. 2020). However, our study calculated the average consumption-related carbon footprint per person of different social classes as ranging between 5.66 and 15.59 tons per year, all exceeding by far the limits set by the remaining carbon budget. The way of life currently practised by each of the four classes in the UK is not sustainable with respect to the limits of the Earth System.

While it has been clear for several decades that climate change is not only a natural but also an anthropogenic phenomenon, only in recent years has it been recognized that tackling the climate crisis will require an understanding of the complex social relations through which it is sustained. This interdisciplinary paper has sought to support the analysis of these complex social relations by navigating the brackish waters between class theory and GHG emissions analysis. By bridging these research fields, we hope to inspire further research that delves deeper into the socio-economic dimensions of environmental degradation. Ultimately, a more nuanced understanding of these dynamics will be crucial in crafting equitable and effective climate policies.

Notes

1. Alternative models of the class structure with a similar scope and degree of abstraction have been put forward, for instance, by Savage et al. (2013) as well as Dörre (2024).
2. The sum is weighted with the survey weights provided by LCF to preserve representativity.
3. GHG emissions tend to increase with income. Using the OECD equivalization scale for income, but direct per capita accounting for GHG emissions, leads to a relative decoupling of emissions from income (Girod and Haan 2010). Thus, while we still expect the income component of our operationalization to drive emission differences, we expect these differences to be smaller than if the operationalization was based on household net income.
4. A special case are households without a completed academic degree but with all households members studying at a university. These are assigned to the new middle class as well if they are in the middle income bracket.

5. The household reference person is the person in whose name the accomondation is rented or owned. Typically this person answered most question on behalf of the household.
6. Expenditure for holidays is not specified in greater detail in the data set. Some of these emissions may be due to air travel or other means of travel and may arguably increase mobility footprints, see Section 4.2.2.
7. This may be exemplified with luxury goods, which are often price-distorted (Veblen 2018), since their demand is based not only on their intrinsic utility or value, but also on their social and symbolic significance.

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Code availability

The `R` code used for the analysis and plots of this paper is available at https://github.com/lindnemi/ghgmiddleclasses (Lindner 2021). We used multiple functions from `R`'s rich package ecosystem (Allaire et al. 2022; Damico 2019; Lumley 2020; Ushey 2022; van Buuren and Groothuis-Oudshoorn 2011; Wickham et al. 2019).

Data availability statement

The LCF data set is available at (Office for National Statistics, Department for Environment, Food and Rural Affairs 2021), CO_2 consumption emissions for the UK are available at (University of Leeds 2021).

Notes on contributors

Michael Lindner received his doctorate from Technical University Berlin in 2023. From 2019 to 2023 he worked as a doctoral researcher on applying Modeling, Simulation and Machine Learning for the Energy Transition at the Potsdam Institute for Climate Impact Research, supported by a fellowship of the Berlin International School on Modeling and Simulation based Research (BIMoS). During this time he developed a strong interest in interdisciplinary research at the intersection of social sciences and mathematical modeling. Since 2024 he works as a research scientist on PyPSA-DE, a sector-coupled optimization model of the German energy system, at the department for Digital Transformation of Energy Systems, Technical University Berlin.

Robert Dorschel is an Assistant Professor in Digital Sociology at the University of Cambridge. His work evolves around the effects and the social making of digital transformations. He conducts research related to digital labour, social class, and the cultural dimension of economic life. Specifically, he has analysed the work ethic and class formation of tech workers, the professionalisation of data scientists, and the power structures within the tech industry. Additionally, he has developed

theoretical work that advocates a broadening of the digital labour concept. Recently, his research has explored the green tech industry as well as the class divides in contemporary society more generally. Robert Dorschel studied sociology and political science at Humboldt-University Berlin, Duke University, and the University of Kiel. In 2023, he completed his PhD in Sociology at the University of Cambridge. His PhD thesis, titled "The Social Codes of Tech Workers", received the Dissertation Award from the Association of Internet Researchers. From December 2022 until August 2024, he served as Assistant Professor in Social Inequality and Diversity at Tilburg University in the Netherlands.

Antonia Schuster received her doctorate from Humboldt University of Berlin in 2024. From 2020 to 2024, she worked as a doctoral researcher at the Potsdam Institute for Climate Impact Research, supported by a fellowship from the Hans Böckler Foundation. Her research focused on social inequalities in greenhouse gas emissions and their societal drivers. A second focus of her work was the challenge of ensuring a fair and just energy transition in Eastern Europe. Drawing on theories from the humanities and social sciences, she took an interdisciplinary approach to climate issues. Since 2023, she has served as the strategic advisor to Prof. Johan Rockström.

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