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Abstract
Climate change mitigation – reducing emissions to zero and substituting fossil fuels through renewable energy within a maximum of two decades – entails major consequences for modern industrial societies and economies. Industrial societies are structurally centred and dependent on work, however, the implications for work are insufficiently studied. We conduct an empirical analysis of the impacts of climate mitigation on work across all sectors of the Austrian national economy. Using a mixed methods approach, we investigate all NACE-classified branches of economic activity, the respective number of persons employed, CO2 emissions, fossil fuel use, renewable energy potential, and the societal importance of work. We find that the impacts of climate mitigation on work are far more substantial than the literature usually suggests. Required are significant reductions of work across all sectors, and its structural reorganisation based on an altered energy basis. Yet, potential for deployment of renewable energy technologies is currently not given for many fields of work that are dependent on fossil fuels. While the category of essential work further indicates the kinds of work that may be prioritised in transformation processes, particularly problematic are those deemed both essential for society and incompatible with climate mitigation. The study provides an initial empirical basis for substantiated differentiation of kinds of work regarding these key aspects of climate change mitigation and structural transformation. It also points to the need for institutions to address these challenges and the problematic ways in which work is organised and held sacrosanct in modern society.

Keywords: climate change mitigation, work, employment,fossil fuels, renewable energy, green jobs, just transition, degrowth, sectoral analysis, structural transformation

JEL: J01, L00, O44, P18, P48, Q40, Q54, Q57

1. INTRODUCTION

To mitigate the high risk of climate change getting out of control and Earth becoming uninhabitable for most life forms, including human beings (Steffen et al., 2018), 195 nations have pledged under the Paris Agreement to keep global average temperature increase well below 2°C, and ideally at 1.5°C above pre-industrial levels (UNFCCC, 2015). Climate change mitigation in line with accordingly remaining carbon budgets means for industrialised countries to substantially reduce greenhouse gas (GHG) emissions to *absolute zero*, to rapidly phase out the use of fossil fuels, and to achieve a structural transformation towards a post-fossil economy based entirely on renewable energy (RE) – within the short timeframe of 15 to 20 years (Allwood et al., 2019; Anderson et al., 2020; Jackson et al., 2019). This also means full decarbonisation must be achieved without relying on 'overshoot' scenarios and contested 'negative emissions technologies' (and associated *net* zero targets). These technologies are unproven, do not currently exist at scale and won't do so in the short timeframe that is decisive, and thus pose a major risk (IPCC, 2018; Minx et al., 2018; Nemet et al., 2018). The focus must therefore be on planning without them and on pursuing realistic, reliable mitigation strategies in the short-term based on existing technologies (Allwood et al., 2019; Anderson & Peters, 2016; Larkin et al., 2018).

With this end in mind, serious climate change mitigation entails profound implications for all sectors of modern industrial economies (Anderson et al., 2020; IPCC, 2018), with major consequences specifically for work and employment across all sectors: Due to RE having different properties than fossil fuels, the energy basis of all economic activity must be completely reorganised, a whole range of industries and associated jobs (e.g., in fossil fuel extraction and energy-intensive production) has to be reduced or entirely phased out, while

certain kinds of work need to be prioritised given their essential importance for society. This is complicated by one aspect in particular: modern industrial societies, welfare states and their growth economies are not only structurally dependent on fossil fuels – but also centred and dependent on work. The resulting conflict between work and the environment, the objection that any measures for emissions reductions must be balanced against concerns about jobs, is one of the main reasons why effective climate protection has regularly been obstructed (Hoffmann & Paulsen, 2020).

Despite the centrality of work for industrialised countries, these impacts of climate change mitigation on work have not been comprehensively studied or sufficiently understood yet. With "the imperatives of a just transition of the workforce and the creation of decent work and quality jobs" (UNFCCC, 2015, p. 2) the Paris Agreement summarises the debate's main focus. Research in this area is usually primarily concerned with job gains and job creation through 'green jobs', e.g. in RE production or retrofitting of buildings (e.g., European Commission, 2019). Potential job losses are discussed as part of a 'just transition' in selected, obvious sectors (e.g., in coal mining) and usually remain on the surface (Snell, 2018). Aside from a few exceptions, there has been little empirical research on exactly which areas of work are susceptible to impact from climate change mitigation in which ways, and what this implies for work-centred societies, as well as for the relevant scientific debates.

This is what this paper aims at investigating. We conduct a sectoral analysis of the impacts of climate change mitigation on work/employment across all branches of economic activity, in terms of carbon emissions reduction towards absolute zero, full substitution of fossil fuels through RE, the jobs accordingly affected and differences regarding their societal importance. We draw on secondary data using the Austrian national economy as a case study of an

average modern industrial economy and 'developed country' signatory to the Paris Agreement. As an exploratory study, the aim is to identify areas in which work is inconsistent with serious climate change mitigation and thus unsustainable, where it needs restructuring, where specific challenges and dependencies are, and what follows for industrial work-centred society. Thus, we aim at gaining understanding of key aspects and wider implications of the pending structural transformation of industrial economies. The following three research questions are addressed:

- (1) Which fields of work are susceptible to impact from climate change mitigation in the short term?
- (2) Which fields of work can/cannot be reorganised on the basis of existing renewable energy technologies?
- (3) What is the susceptibility of fields of work that are essential for society to fulfil its needs and functions?

In the following, we first situate the study in the relevant field of research on work and climate change (mitigation), or the environment and sustainability more broadly. We then introduce our methods, before presenting the results, discussing their implications, and drawing conclusions.

2. WORK AND CLIMATE CHANGE MITIGATION

Research on work and climate change is in its infancy, fragmented and inconsistent. It is therefore useful to demarcate first what this paper is not about.

The correlation of working hours and environmental/climate impacts, including greenhouse gas emissions, carbon footprint, ecological footprint, and energy consumption, both on household and on cross-national levels, and for countries both of the global North and the global South, has already been assessed in quantitative terms (Fitzgerald et al., 2015; Hayden & Shandra, 2009; Knight et al., 2013; Nässén & Larsson, 2015; Rosnick & Weisbrot, 2007). Hoffmann & Paulsen (2020) have classified these findings in qualitative terms, differentiating four analytically distinct factors of environmental impacts of work itself, regarding its immediate impacts as well as the time-use, income, infrastructure and mobility patterns it commands. Therefore, it has already been shown that work clearly is a central driver of climate change. However, these studies address work and working hours broadly, and do not distinguish different fields of work regarding their varying climate impacts, fossil fuel dependency and potential for RE deployment, or their societal importance.

A related aspect are the physical impacts of climate change itself on work and production, which have been studied in more detail (e.g., Burke et al., 2015). These impacts play a highly relevant role not only in certain sectors (e.g. in agriculture, fisheries and forestry, tourism, health, heavy industry, infrastructure and energy, finance and insurance) (ETUC et al., 2007; Rosemberg, 2010), but also for the physical ability of human beings themselves to work under deteriorated environmental conditions (Smith et al., 2016). Climate change *adaptation* in relation to work is thus another important area of research (Rosemberg, 2010; UNEP & Sustainlabour, 2008).

The focus of this paper – work and climate change *mitigation* – has so far received limited attention; most research in this area has been done by trade union think tanks, international organisations and government agencies published as policy papers and other grey literature.

The literature in this specific area writing from the stance of 'status quo-oriented mainstream' usually does not question continued economic growth and market-based economic organisation, and accordingly does not assume any drastic changes in the overall levels of employment or the ways in which work is currently organised. The most prominent concept here is 'green jobs', which under UNEP et al.'s (2008) definition comprises jobs in specific sectors that contribute to preserving or restoring environmental quality. However, it also includes vaguely defined "shades of green" in conventional jobs, including those in high-carbon or otherwise energy-intensive industries, such as cement or steel (UNEP et al., 2008). Under a different name, the 'EU taxonomy' as recently adopted by the European Commission provides a similar classification of 'environmentally sustainable economic activities', which also include such problematic activities under certain thresholds of 'acceptable' pollution (European Commission, 2021). Very little attention is being paid to 'non-green' jobs, i.e. clearly unsustainable work, and the need to discontinue such occupations.

To the contrary, what is typical for 'green economy' and green jobs discourses of this kind is their predominant focus on predictions of job gains and potential for 'green growth'. Positive employment impacts, or at least net gains when balancing job losses against job creation (Bowen, 2012; ETUC et al., 2007; ILO, 2012; Rosemberg, 2010; European Commission, 2019), are emphasised while there is no comprehensive investigation how many jobs in which sectors will face serious issues given their fossil energy basis. Such approaches grossly underestimate the scale of the challenge posed by climate change mitigation in line with the Paris Agreement and respective absolute zero emissions targets in the short term. While findings of the effects on work/employment are inconsistent, they appear overall unrealistically moderate, and even 'worst case' scenarios still seem to be based on an unfounded optimism about the continued existence of conventional jobs in fossil fuel-

dependent sectors, such as the cement industry (UNEP & Sustainlabour, 2008; Bassi et al., 2008). This is likely due to ideological reservations, vague and unrealistic assumptions about long-term targets and the feasibility of speculative 'net zero' pathways, and methodological issues with abstract macroeconomic modelling.

In contrast to such status quo-oriented approaches, there is a strand of research which acknowledges the need for more far-reaching changes of work and the economy, which, however, should not go too far. 'Sustainable work' as one concept in this area is ill-defined – there are just few, and quite incoherent existing notions of sustainable work. Sustainable work as defined by UNDP (2015) does acknowledge that some work is detrimental to human development and the environment and therefore needs to be reduced or terminated, however without even cautiously questioning the notion's conventional growth and development framework. In contrast, the approach to sustainable work by Littig (2018) and Barth et al. (2019) argues for a fundamental social-ecological transformation beyond 'green economy' proposals. Yet, it remains rather theoretical and does not address the issue of climate change mitigation or other ecological problems specifically. This approach is also uncritical insofar as it naturalises work by obscuring its specific modern cultural and institutional form, and as it takes the typically modern elevated moral status of work as intrinsically good and as an end in itself for granted (Hoffmann, 2022).

A different approach in this second category is the prominent notion of 'Just transition', which addresses the issue head-on that some industries and associated jobs will have to disappear for ecological and climate reasons. However, Snell (2018, p. 550) notes that the concept of just transition "lacks both conceptual clarity and empirical evidence of its practical applications". A further problem is that 'just' primarily means justice for the workers in the

industries immediately affected (Hyde & Vachon, 2019), which is at odds with claims to intergenerational, global, or 'climate justice' as put forward by those who suffer first and foremost of the negative impacts of work and unmitigated climate change.

'Just transition' has its origins in a trade unions context, and it was the European Trade Union Confederation and other labour organisations who acknowledged explicitly that "no sector will be able to cut itself off from the consequences of (…) measures taken to combat climate change" (ETUC et al., 2007, p. 182). While this is completely right, related debates usually focus on isolated sectors only, not on the economy in its entirety. The focus lies further on obvious ones such as fossil fuel production (and here mostly on coal, much less on oil and gas), energy-intensive manufacturing, transport, electricity generation, or construction (ETUC et al., 2007; Rosemberg, 2010; Bassi et al., 2008). Specifically energy-intensive, high-carbon industries such as iron and steel, cement, aluminium, and similar 'hard to abate' sectors have, justifiably, received attention (Bassi et al., 2008; Rosemberg, 2010). However, "[z]ero-emission options have been less explored and are less developed in the energy-intensive basic materials industries than in other sectors" (Åhman et al., 2017, p. 634). This is presumably for reasons of undeniable fossil fuel dependency in the absence of feasible technological alternatives, insufficient climate targets, and economic considerations regarding international competitiveness (which is why these industries are allocated permits under prevailing emissions trading schemes for free). Accordingly, neither is there any considerable research on the implications of climate mitigation in these sectors for work, despite their importance for large numbers of well-paid, unionised jobs. An important exception to this is a recent study on the case of Austria specifically, which (amongst various aspects) investigates the effects of decarbonisation on employment, however only in emissions-intensive sectors under the EU-ETS, in particular in manufacture of motor vehicles (Streicher et al., 2020).

Otherwise there is much focus on renewable energy production, where, again, the emphasis is usually on this sector's job creation potential (Garrett-Peltier, 2017). To the best of our knowledge, there is very little discussion in the relevant scientific literature of the fact that RE has fundamentally different properties than fossil fuels, which is why direct substitution of fossil energy sources for renewable ones is not possible. This will have major implications for work under an altered energy regime. Exceptions to this gap are Sorman & Giampietro (2013), or the historical study by Malm (2013) on the transition from renewable energy to fossil fuels in 19th century Britain.

Overall, the literature in this second category acknowledges to some degree that fundamental changes for work are inevitable. However they do not offer a comprehensive account of the situation by focusing on selected sectors only, often appear hesitant to question the defining structures of the present industrial-capitalist economy, and remain unclear about the depth of the structural transformation of modern-day work and its energy basis that effective climate change mitigation requires.

This is what a third area of research tries to address, the literature on degrowth/post-growth and related critiques of modern society. Recurring work-related debates include those on work time reduction (e.g., Liebig, 2021), on the question whether there will be less or more (physical) work to do in an energy- and resource-constrained future (Sorman & Giampietro, 2013; Kallis, 2013; Knight et al., 2013; Frey, 2019), on the proposition that a shift to labour-intensive, low-productivity sectors is needed (e.g., Mair et al., 2020), or those suggesting a focus on decommodification and commonisation of care, the latter drawing on feminist theory in particular (Dengler & Lang, 2021). Degrowth research also emphasises that for ecological reasons, the purpose of production should be questioned (Mair et al., 2020) and a reduction of

unwanted or unnecessary economic activity/work needs to be organised, which has been framed as ‘selective degrowth’ (Latouche, 2009; Kallis, 2011). Similarly, Graeber (2019) has opened the discussion on identifying ‘bullshit jobs’, i.e. work that is, besides pointless and unnecessary, even ‘pernicious’. Including the ecological variable explicitly, Rübner Hansen (2019) coined the related concept of ‘batshit jobs’, i.e. work “that contributes to destroying the climate and environment” as part of “a kind of systemic madness” where “making a living is also a part of unmaking life on many scales”.

However, there is clearly a gap even in degrowth research *what kind* of work exactly may be identified as un-/necessary, harmful, un-/sustainable or otherwise un-/wanted, as part of a comprehensive structural transformation of the economy. The recent study by Hardt et al. (2021) is among the first to research this in more detail with an economy-wide approach encompassing all sectors. In contrast to the writings of degrowth pioneers (e.g., Illich, 1978; Gorz, 1982, 1989), more recent degrowth debates also have shifted their focus away from critically scrutinising work itself in its socially, politically, economically and culturally predominant, and highly problematic, function and organisational form (an exception being Foster, 2017).

To summarise, for the purposes of this study there is a wealth of literature to draw and build on, however, the relevant research is overall vague and insufficient, specifically with regard to the scale and complexity of the challenge ahead.

3. METHODS

To investigate the fields and kinds of work that (1) are susceptible to impact from climate change mitigation, (2) can or cannot be reorganised on the basis of existing renewable energy

(RE) technologies, and that (3) are essential for society to fulfil its needs and functions, the main factors of interest needed to be identified first. Key aspects of climate change mitigation from a physical science perspective are *carbon dioxide (CO_2) emissions* (and their reduction to zero), *use of fossil fuels* (and their phase-out), as well as full *substitution of fossil fuels through RE* (Jackson et al., 2019; IPCC, 2021). Including the aspect of work, this was related to the *number of persons employed* (i.e. the jobs potentially affected by mitigation measures), and to the notion of *'essential work'*, i.e. the kinds of work that are vital for the functioning of society (Herzog et al., 2022) and accordingly require special consideration in transformation processes. Data collection on these five aspects followed a mixed methods approach, using secondary data (publicly provided by Statistics Austria for the contiguous baseline years 2016 and 2017), qualitative expert assessments as well as government-issued documents. Further details are given below.

We conducted a sectoral analysis, using the Austrian national economy as a case study of an average modern industrial economy. This means that we followed national and production-based greenhouse gas (GHG) accounting, which assigns emissions to the specific country where they occur during production. This approach was most reasonable for our purpose, because under the prevailing UNFCCC regime the national level and production-based accounting are decisive for policy-making (Steininger et al., 2016), and thus for effective climate change mitigation. Other studies have already investigated different aspects of consumption-based GHG emissions accounts for the case of Austria, drawing on various types of input-output analysis; none of them focusing on work specifically (Steininger et al., 2018; Nabernegg et al., 2019; Smetschka et al., 2019).

In order to gain comprehensive understanding of the sectoral impacts of climate mitigation on work across the Austrian economy in its entirety, we aimed at analysing all economic sectors (i.e. fields of work). We thus identified all branches of economic activity in Austria as internationally standardised according to the ÖNACE-08 classification, i.e. the current European and Austrian version of the International Standard Industrial Classification of All Economic Activities (ISIC). This was done primarily on the first two levels of disaggregation, sections and divisions (Statistik Austria, 2018a). We then examined all economic sectors with regard to the five aspects introduced above.

First, secondary data was collated on the number of jobs or persons employed in 2017 in each sector, in order to see how many jobs in which branches of economic activity exist and could accordingly be impacted. Publicly available secondary data from Statistik Austria (2018b) was drawn on.

Second, since GHG emissions must be reduced to absolute zero for climate mitigation, it is necessary to know how much is emitted in which sectors. This in turn indicates the susceptibility of each sector to impact from emissions mitigation. Therefore, secondary data, again publicly available from Statistik Austria (2018c), on carbon dioxide emissions in tons in 2016 were compiled for each sector (taken from 'Luftemissionsrechnung 2008-2016: Ergebnisse für Wirtschaftsbereiche und private Haushalte', data sheet 'CO_2 total'). The focus was only on CO_2 emissions as the most relevant GHG given the near-linear relationship between CO_2 emissions and global warming (IPCC, 2021).[1]

[1] Sheet 'CO_2 total' was chosen although 'CO_2 fossil', 'CO_2 biogenic' and 'CO_2 other sources' are distinguished in the data set. This stands in certain conflict to the following aspect (fossil fuel use) that only counts fossil energy inputs, however, for climate mitigation to be successful all sources of CO_2 need to be taken into account. We did not consider other greenhouse gases or impacts through other drivers of climate change, e.g. land use changes.

Third, because CO_2 is mainly caused through the combustion of fossil fuels, climate mitigation is primarily a matter of ending the use of fossil fuels including all processes dependent on them. Thus it needs to be understood how much fossil fuels are used in each sector. Fossil fuel use in Terajoules in 2016 was calculated per sector from Physical Energy Flow Accounts (PEFA) 2016, Table B 'Physical use table for energy flows' (Statistik Austria, 2018d). This table was chosen because it is total use or input of fossil fuels into economic sectors that matters for our purpose, irrespective of what they are used for (transformation, non-energy, or energetic i.e. directly emission-relevant use). Moreover, the respective shares of fossil energy in electricity generation (28.3%) as well as in long-distance heat generation (53.9%) have been calculated from the Austrian energy mix in 2016 (BMNT, 2018) and then added to the sum of all fossil fuel fractions (rows 15-28) in the PEFA table.

Fourth, due to the fundamentally different properties of fossil fuels and (the various kinds of) RE, these sources of energy cannot simply replace each other. Likewise, substitution of fossil fuels through RE is not possible for all kinds of work. The potential for, or problems with, large-scale deployment of RE technologies across sectors ('RE potential') thus becomes a relevant concern. For this aspect, a different approach was taken in the form of expert assessments whether an economic activity can in principle be reorganised on the basis of *existing* RE technologies, only conditionally, or clearly not. This implies the full potential for electrification, that fossil fuels are not essential for the production or work process (due to their specific material and energetic properties both for non-energetic and energetic use), and that necessary intermediate products and services are independent from fossil fuels as well. 'Existing' means, again, the crucial assumption that the respective technologies are currently available *at scale*, regardless of potentially new technologies that are being discussed, researched or tested at pilot-plant scale, because their development for large-scale substitution

of fossil fuels will take longer than the relevant time span of ten to fifteen years decisive for staying within the temperature limits under the Paris Agreement – if they will materialise at all (Allwood et al., 2019; Anderson & Peters, 2016; Larkin et al., 2018; Nemet et al., 2018). All economic activities were further assessed as to their RE deployment potential in principle, irrespective of the questions of scale, quantity, growth, and other conditions of organisation, which evidently greatly affect their future feasibility (see Discussion).

Fifth, the ways in which different fields of work are impacted by climate mitigation needs to be understood in relation to their varying importance for fulfilling fundamental societal needs and functions. This indicates 'essential' areas of work that require special attention and need to be favoured over other, more dispensable ones in the pending transformation process. It also points to sectors in which major conflicts can be expected to arise. Here, again a different approach to data collection was chosen. Empirically, the closest there currently is to draw on are the lists of 'essential work' (or workers, occupations, industries, infrastructures) that governments all over the world have recently issued as part of the measures to contain the Coronavirus pandemic. Evidently, these lists are not ideal as empirical material for our context, but can still be taken as an approximation or heuristic to give rough indications of the kinds of work that can be regarded as essential for society to function under prevailing conditions. In addition to such a list issued by the Austrian government (Bundeskanzleramt, 2020), similar lists published by the European Commission (2020), as well as the Italian (Governo Italiano, 2020), German (BBK, 2020), and US-American (CISA, 2021) authorities were drawn on for comparison.[2]

Data on all these factors were accordingly calculated and/or compiled in a table with a two-dimensional matrix, which was then used as a basis for the analysis.

[2] The methodological approach taken here will be improved for the final version of this paper.

4. RESULTS AND DISCUSSION

4.1 Climate-friendly, Low-impact Work Currently does Not Exist

With regard to RQ(1) 'Which fields of work are susceptible to impact from climate change mitigation in the short term?', i.e. entirely phasing out fossils fuels and reducing emissions to absolute zero over the next 15-20 years, it is the aspects of fossil fuel use and CO_2 emissions that are decisive. It was found that overall fourteen branches of economic activity, i.e. fields of work, are highly dependent on fossil fuel usage; they exhibit the highest fossil fuel uses in terms of at least five-figure numbers (in TJ). These include: Crop and animal production etc. (ÖNACE code A01), Manufacture of food and beverage products (C10-11), Manufacture of paper and paper products (C17), Manufacture of coke and refined petroleum products (C19), Manufacture of chemicals and chemical products (C20), Manufacture of other non-metallic mineral products (C23), Manufacture of basic metals (C24), Electricity, gas, steam and air conditioning supply (D35), Construction, civil engineering etc. (F41-43), Land transport and transport via pipelines (H49), and Air transport (H51).[3] Concerning CO_2 emissions, among the 'top ten' sectors in terms of the highest emissions moreover counts Manufacture of wood and of products of wood and cork etc. (C16), besides the aforementioned sectors.

An additional, less obvious aspect that should be taken into account here – although it cannot be accurately measured or quantified and is thus more speculative – are the kinds of work that are not directly highly remarkable in terms of emissions or fossil fuel use when only the actual production or work process as such is considered. However, they are affected by climate change mitigation because demand for them (or the respective products and services)

[3] The exact figures per sector codes are as follows: A01: 11,300 Terajoules (TJ); C10-11: 20,900 TJ; C17: 26,800 TJ; C19: 436,500 TJ; C20: 80,000 TJ; C23: 25,900 TJ; C24: 137,600 TJ; D35: 140,300 TJ; F41-43: 12,300 TJ; H49: 35,800 TJ; and H51: 38,800 TJ.

will decline or cease entirely due to climate mitigation efforts (e.g. bans, or increases in production costs). These fields of work include, for example, the (sub-)branches Extraction of crude petroleum and natural gas (B06), Manufacture of motor vehicles, trailers and semi-trailers (C29; for a wealth of details concerning this sector see Streicher et al., 2020), Manufacture of air and spacecraft etc. (C30.3), Manufacture of military fighting vehicles (C30.4), or Wholesale and retail trade and repair of motor vehicles (G45).

Based on the analysed data for CO_2 emissions and fossil fuel use, this overall means that a total number of 845,900 jobs or persons employed is most susceptible to impact resulting from short- to mid-term climate change mitigation. This amounts to around 20% of the total Austrian workforce in 2017. When taking the last mentioned, not quantified, aspect into account, this number increases by 114,600 to nearly a million jobs in sum. Note that for this rough calculation only the highest impacts (in terms of fossil fuel use above five-figure numbers and the top ten sectors with regard to CO_2 emissions) were considered. The total number of 'vulnerable' work rises accordingly if sectors with relatively lower emissions or fossil fuel figures are also taken into account.

In fact, the data shows that there is *no* sector or field of work (apart from two marginal ones) that is unremarkable in terms of CO_2 emissions and fossil fuel use; almost all sectors emit more than 10,000 tons of carbon per year, and many much more than that. What is more, those sectors typically associated with low environmental impact (e.g. P85 Education, or Q86-88 Human health and social work activities) quite to the contrary tend to exhibit considerable climate impacts (P85: 409,605 t CO2; Q86-88: 154,126 t CO2). The strategy often discussed in the literature of shifting employment to such allegedly low-impact, low-productivity

sectors (e.g. Mair et al., 2020; Hardt et al., 2020), though reasonable in theory, would therefore under present conditions not benefit climate mitigation.

It follows that the overall implications of climate mitigation for work are far more substantial and involve considerably more work in more sectors than usually suggested. This is clearly at odds with the (overly positive) literature and debates on 'green growth' and 'green jobs', GND, or just transition which, as mentioned above, typically predict only moderate changes or even job creation potential induced by climate mitigation policies (for an initial overview see GHK, 2009). This clearly underestimates the scale of the challenge, especially when seen across all sectors of the economy and not just selected, isolated ones. Instead of job creation that evidently seems to miss the point, the debate should much more systematically address the conditions for substantial, quick and socially sustainable reductions of work in line with serious climate mitigation targets (Frey, 2019). The reduction of work across sectors should thereby not only be understood as an (unwelcome) side effect of mitigation measures (such as increasing carbon costs), but as a mitigation measure in itself.

4.2 An Empirical Basis for 'Selective Degrowth'

The narrative behind the promise of 'green jobs' and 'green growth' rests on the assumption that all kinds of work and economic activity can be fully reorganised on a climate-friendly energetic basis. However, as noted above, transitioning to 100% renewable energy is not just a matter of substituting one type of energy for another. RE has fundamentally different properties compared to fossil fuels; this concerns (a) energy density, (b) EROI (energy-return-on-investment), (c) storability and transportability which affects (in)dependence from/on space and time (Malm, 2013), and (d) suitability for different energy uses (fossil fuels can be burnt and are thus suitable for electricity, heat, and motion, while RE can only be used for

electricity, except biomass). Accordingly, much less energy will be available in a future economy based on RE, and under radically different conditions.

Regarding RQ(2) 'Which fields of work can/cannot be reorganised on the basis of existing renewable energy technologies?' the answer is thus not straightforward but different aspects need to be distinguished. For three sectors RE potential has been identified as 'no': B06 Extraction of crude petroleum and natural gas; C19 Manufacture of coke and refined petroleum products; and H51 Air transport. A small number of 11,500 persons employed in these sectors would be affected by according measures.

A range of areas of work can 'conditionally' be reorganised based on RE technologies, for different reasons. One difficulty is dependency on very high temperatures or industrial process heat (IPH) which is not easily possible to obtain through RE that in most cases is made available as electric energy. The potential for electrification based on RE technologies is limited in certain cases, especially in the large amounts required for IPH. Affected by this problem are the (sub-)branches C20 Manufacture of chemicals and chemical products; C23.1 Manufacture of glass and glass products; C23.5 Manufacture of cement, lime and plaster; C23.6 Manufacture of articles of concrete, cement and plaster; C24 Manufacture of basic metals; and C25 Manufacture of fabricated metal products etc.[4]

One other reason for RE potential qualified 'conditional' is the dependency of sectors or production processes on fossil fuels not for their energetic, but their material, non-energy

[4] Within these sectors, partly very different manufacturing processes are aggregated which at times complicates the assessment: for instance, the sub-branches C24.1 Manufacture of basic iron and steel and of ferro-alloys as well as C24.2, C24.3, and C24.5 that are all concerned with processing steel are presently not prepared to operate with renewable IPH, while e.g. C24.42 Aluminium production is often electrified and partly run on RE. Renewable electricity in the large amounts required for IPH is very difficult to obtain based on the current state of technology. Awareness in the respective industries is finally rising and R&D undertaken (for an overview cf. US Department of Energy, 2015). For example, in Linz, Upper Austria, a hydrogen/electrolysis pilot plant for steel and other metal manufacturing powered be RE has been built by steel manufacturer Voestalpine.

properties. The branches of economic activity that are dependent on fossil resources for direct material use, as reducing agent or other chemical reactants include C20 Manufacture of chemicals and chemical products; C22 Manufacture of rubber and plastic products; and again C24 Manufacture of basic metals (note C19 has already been excluded). The question whether such non-energy uses can continue under climate change mitigation scenarios to our knowledge remains unaddressed in the literature.

A third reason certain branches of economic activity only have limited RE deployment and reorganisation potential is their direct use of fossil fuels for transportation or for energy generation and transformation in large amounts, which applies to the sectors D35 Electricity, gas, steam and air conditioning supply; G45 Wholesale and retail trade and repair of motor vehicles etc.; G46 Wholesale trade, except of motor vehicles; F41-43 Construction, civil engineering, etc.; H50 Water transport; O84 Public administration and defence etc.; and R93 Sports, amusement and recreation activities.

Fourthly, a range of sectors is dependent on fossil fuels indirectly through the use of intermediate products (including not only energy but also metals, synthetic material etc.) that are either directly or in turn indirectly based on fossil energy technologies to which the aforementioned issues apply, affecting e.g. C25 Manufacture of fabricated metal products etc.; C26 Manufacture of computer, electronic and optical products; C27 Manufacture of electrical equipment; C28 Manufacture of machinery and equipment n.e.c.; C29 Manufacture of motor vehicles, trailers and semi-trailers; C30 Manufacture of other transport equipment; F41-43 Construction; civil engineering; etc.; J59-60 Motion picture production, sound recording etc.; J61 Telecommunications; and J62-63 Computer etc. and information service activities.

Overall, the potential for reorganising work on the basis of RE is impossible or to a considerable extent limited for around 1,214,000 jobs or persons employed, or 28.5% of the total Austrian workforce in 2017. This number is subject to issues of (dis-)aggregation as mentioned, of varying assumptions in the assessments, and may accordingly be to some extent lower or higher, but indicates the dimension of what is at stake. For an illustration see the figures 'Employment, CO_2 Emissions, and Renewable Energy Potential per Branch of Economic Activity in Austria 2016' and its 'Top 10 Emissions' selection (at the end of the manuscript).

A whole range of economic activities and associated kinds of work thus currently cannot be 'greened' due to their dependency on fossil fuels. Certain technologies may (or may not) become feasible in several decades; however the ones that currently most hopes are pinned on, such as various processes based on hydrogen, cause many new unresolved issues (e.g., hydrogen production being highly energy-intensive). Moreover, it should not be underestimated that the production of RE technologies themselves is energy-intensive, in many cases ecologically highly destructive, and dependent on metals that are increasingly problematic from a climate (Watari et al., 2020) as well as human rights perspective. Either way, none of these new technologies – even if they were available and deployed at scale in time which is very unlikely – can compete with the high EROIs and high energy density of conventional fossil fuels which made the development of modern economies possible in the first place (Malm, 2013). Biophysical realism is therefore advisable against overly optimistic scenarios solely based on 'technological innovation'. Thus, under climate change mitigation imperatives and rapidly shrinking carbon budgets, there are absolute limits to deal with. This implies that work and production cannot be upheld at the present scale of energy

consumption, and that questions of scale, growth, phasing out of industries, and economic restructuring are all-important (which debates on ‘green jobs’ usually deny).

This also means that in addition to what has been discussed above about necessary reductions of work, the approach taken here indicates that the most substantial issues arise in fields of work that presently cannot be reorganised on the basis of RE – here, work would not only need to be substantially reduced, but partly even entirely phased out, at least temporarily, to ensure effective climate change mitigation. While phasing out production and calls for working time reduction are nothing new at all (especially in degrowth debates), our approach allows for a crucial *differentiation* of kinds of work: not only should the overall volume of work be reduced, but reductions should be begun with in the most harmful sectors in terms of emissions and fossil fuel use that cannot be reorganised based on RE. Our study indicates which ones these sectors and fields of work are, and thus provides an empirical basis for what has been called ‘selective degrowth’ (Latouche, 2009; Kallis, 2011; Hardt et al., 2021).

However, reducing work selectively according to climate-relevant criteria does not suffice. Under conditions of reduced energy supply, there cannot be any predetermined judgement about the ‘right’ uses. The very large amounts of electricity necessary for e.g. hydrogen production will most likely have to compete with other uses, and overall ‘security of supply’ for all kinds of energy uses will be increasingly difficult to uphold. This necessitates debates about the purpose of work in relation to societal needs – about the kinds of work for which demands are more or less justifiable or where security is more or less important when under RE conditions overall security cannot be granted under all circumstances, and clearly not for the present scale of energy consumption. Thus, besides questions of scale, the question of the societal importance of work needs to be dealt with.

4.3 Essential Work Vs. the Climate?

Turning to RQ(3) 'What is the susceptibility of fields of work that are essential for society to fulfil its needs and functions?', the lists of work or occupations classified as essential by the Austrian and other governments are far from consistent. Just a small number of items appear uncontested, namely the kinds of work concerned with provisioning of public health and health care (Q86), agriculture and food production (A01, C10), energy (D35), water and wastewater (E36-37), transportation and logistics (H49), telecommunications and information technology systems (J61), financial and insurance services (K64-66), as well as state and administrative incl. public safety, law enforcement and emergency services. Besides these commonalities, the lists differ, for example, with regard to child and elder care and social work activities (Q87-88), education (P85), chemicals (C20) and other 'critical' manufacturing, retail trade (G47), and waste management (E38-39).[5] Regardless of details in classification, it is clear that currently none of these fields of essential work are compatible with climate mitigation, albeit to varying extents.

However, it would evidently pose serious problems if such kinds of work deemed 'essential' were to be phased out for reasons of climate mitigation – they cannot simply be reduced due to their essential importance for the functioning of society, and need to be favoured over others in processes of sustainable reorganisation. This necessitates differentiation of kinds of work not only according to their climate impact, but also according to their societal importance. For example, should priority be given to the manufacture of RE technologies and infrastructure, agriculture and food production, or the health care sector (all being very

[5] The Austrian list additionally mentions, i.a., security, legal, and cleaning services, veterinary activities (M75), postal and courier activities (H53), or motor vehicle and bicycle repair services.

emissions intensive), or can we take responsibility for wasting scarce carbon budgets for manufacture of consumer electronics, SUVs, military vehicles, or spacecraft?

What our RQ3 points to, and further complicates the matter, is that specific challenges arise in sectors or fields of work that clearly cannot be upheld in their present form under climate mitigation imperatives, but are essential for society under current circumstances. Note that for the analysis in this part, official lists were drawn on that judged on the societal importance of work against the aim of not only meeting basic needs, but upholding a certain kind of social structure: the functioning of the present type of society, i.e. of modern capitalist societies with their fossil fuel based, financialised, and growth-oriented economies and military-dependent, competitive nation states. 'Essential' has thus not been assessed against the aim of creating a social structure compatible with sustaining life on Earth, i.e. an ideal future sustainable society in line with ambitious climate goals – this would require going beyond the status quo. Consequently, distinguishing kinds of work as to their importance for the flourishing of society is highly context-dependent and ultimately deeply political (Hoffmann, 2022).

Exactly this becomes a problem in the pending transformation process because it means difficult implications for structural transformation if work under present conditions classified as essential is at the same time in certain instances work that must be considerably reduced or even discontinued under climate mitigation agendas, e.g. in the aviation, chemical, steel, or fossil fuel industries, or the defence sector. In these fields of work in particular there is great conflict potential, they should be 'hotspots' of concern in transformation politics.

Institutionalised processes are needed that are capable of organising the phasing out of such work in a socially sustainable, organised, and democratic way. At the core of this is the question of the societal value and purpose of work, which includes essential and meaningful,

but also pointless and harmful work ('bullshit' or 'batshit' jobs; see Graeber, 2019; Rübner Hansen, 2019). The idea of 'green jobs' against this backdrop further raises the risk of ongoing externalisation of costs and outsourcing of dirty industries while keeping only 'clean' employment in Austria – and thus avoiding debates, for example, which amounts of iron or steel are sufficiently important to produce them domestically, at the expense of other energy uses. Such debates on the ends and purpose of production and work in relation to societal needs and goals are necessarily contested (Graeber, 2019; Voswinkel, 2015), but cannot be avoided if climate mitigation is taken seriously.

5. CONCLUSIONS

We conducted an empirical analysis of the impacts of climate change mitigation on work across all branches of economic activity, in terms of CO_2 emissions, fossil fuel use, renewable energy potential, the jobs consequently affected, and their varying societal importance. The project was novel in that it addressed the biophysical aspects of this issue in order to ground the debate on work and climate mitigation or sustainability transformation more broadly in a fundamental aspect of material reality.

Our findings include that nearly all work in a modern industrial economy such as Austria's is currently inconsistent with climate change mitigation, and thus going to be affected by it. Despite immediate problems with fossil fuel use and according carbon emissions, a transformed economy based on RE will imply that overall much less energy is available, and this energy will have entirely different properties than fossils fuels. Thus, all fields of work need to be reorganised based on an altered energy basis, while approximately 30% of jobs will face serious issues due to their dependency on fossil fuels. Most technological promises

are not only theoretically uncertain and ecologically highly problematic, but also at odds with the very short time horizon of the Paris Agreement, and can thus be ruled out as short-term 'solutions'. Needed are overall substantial reductions of work and a structural transformation of the organisation of work, begun with in the most harmful sectors that cannot be reorganised based on RE, which puts whole industries into question. The relevant scientific debates largely underestimate the scale of this challenge.

The chosen approach of investigating these issues across all sectors of the economy not only provides a comprehensive account of the situation, it also allows for substantiated comparison and differentiation of fields or kinds of work. This is conducive to developing the concept of 'selective degrowth', which has so far only existed in rhetorical terms but not been fleshed out empirically (Hardt et al., 2021).

Differentiation is also needed regarding the specific challenges that arise in those fields of work that are considered essential for societal welfare, which accordingly need to be prioritised in transformation processes. Of specific concern are those kinds of work that are deemed essential but at the same time cannot be sustained under climate mitigation terms and therefore indicate high conflict potential; these are 'hotspots' of concern in transformation politics. Our study provides an initial empirical basis for such differentiation, i.e. giving reasons *on what grounds* certain kinds of work are to be reduced, reorganised, phased out, or prioritised. Distinguishing various kinds of work as to their ecological impact, purpose and social importance is at least unusual in an economic system that usually regards aggregate growth, full employment, and job creation as ends in themselves as its main economic goals, regardless their context or adverse impacts.

There are currently no adequate institutions that are capable of dealing with these issues in an organised and democratic way. Novel kinds of deliberation are needed, oriented towards yet to be created institutions of economic democracy (Johanisova & Wolf, 2012). The German or Czech 'coal commissions' (and similar ones in other countries) are first, grossly insufficient but nevertheless promising examples of how such institutions of systematically reducing or phasing out entire industries could look like.

Finally, it is clear that the issues discussed here are not isolated in just some sectors, but structural and pervasive problems with the way in which work is organised in modern 'work society'. Crucial for industrial work-centred society would thus be to overcome certain structural dependencies on work, in norms and values as well as policies and institutions. For example, for socially sustainable reductions of work it would be necessary to reform central welfare state institutions that are dependent on work. Moreover, work can only be reduced substantially if the specific modern cultural attitudes towards work and productivism are questioned and overcome, according to which work is an end in itself regardless what is done and at what cost (Frayne, 2015; Hoffmann & Paulsen, 2020).

Limitations and future research: While this has been an initial exploratory analysis at the national level for Austria, it provides an approach applicable to any other country or region that provide the relevant NACE/ISIC-classified statistics. To a certain extent, also the *findings* are transferrable to other industrialised economies and fields of work. More detail in NACE-categories and levels would provide interesting insights, however this might be complicated by a lack of according data on employment or climate impacts. Future work would also need to expand analysis to other GHGs, and to other ecological impacts caused by work, not least RE development. Moreover, the different metals and minerals used in manufacturing

processes need all be studied in detail as regards their properties, availability, climate impacts and substitution potential (e.g. concerning those metals summarised in branch C24: iron, steel, aluminium, lead, zinc, tin, copper etc.). Overall, this study furthered understanding of key aspects of societal implications of climate change mitigation and structural transformation.

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REFERENCES

Åhman, M., Nilsson, L. J., & Johansson, B. (2017) Global climate policy and deep decarbonization of energy-intensive industries. *Climate Policy, 17*(5). 634-649. DOI: 10.1080/14693062.2016.1167009.

Allwood, J. M., Dunant, C. F., Lupton, R. C., Cleaver, C. J., Serrenho, A. C. H., Azevedo, J. M. C., Horton, P. M., Clare, C., Low, H., Horrocks, I., Murray, J., Lin, J., Cullen, J. M., Ward, M., Salamati, M., Felin, T., Ibell, T., Zhou, W., Hawkins, W. (2019) *Absolute Zero: Delivering the UK's climate change commitment with incremental changes to today's technologies.* DOI: 10.17863/CAM.46075.

Anderson, K., Broderick, J. F., & Stoddard, I. (2020) A factor of two: how the mitigation plans of 'climate progressive' nations fall far short of Paris-compliant pathways. *Climate Policy, 20*(10). 1290-1304. DOI: 10.1080/14693062.2020.1728209.

Anderson, K., & Peters, G. (2016) The trouble with negative emissions. *Science, 354*(6309). 182-183. DOI: 10.1126/science.aah4567.

Barth, T., Jochum, G., & Littig, B. (2019) *Transformation of what? Or: The socio-ecological transformation of working society.* IHS Working Paper, No. 1. Vienna: Institute for Advanced Studies (IHS).

Bassi, S., Anderson, J., & Kuik, O. (2008) *Burden Sharing: Impact of Climate Change mitigation policies on growth and jobs*. European Parliament, Policy Department Economic and Scientific Policy. https://ieep.eu/publications/burden-sharing-impact-of-climate-change-mitigation-policies-on-growth-and-jobs.

BBK (2020) COVID-19: Übersicht Kritischer Dienstleistungen. Sektorspezifische Hinweise und Informationen mit KRITIS-Relevanz. https://www.kritis.bund.de/SharedDocs/Downloads/Kritis/DE/200414_Covid19_UebersichtKRITI S.pdf?__blob=publicationFile.

BMNT (2018) Erneuerbare Energie in Zahlen 2017, Entwicklung in Österreich, Datenbasis 2016. https://www.bmnt.gv.at/dam/jcr:61650a7c-04aa-49b7-a091-2643d52f0a2b/BMNT_EEIZ2017-Factsheet_DT.pdf.

Bowen, A. (2012) *'Green' Growth, 'Green' Jobs and Labor Markets*. Policy Research Working Paper 5990. Washington, DC: World Bank.

Bundeskanzleramt (2020) Gesamte Rechtsvorschrift für Vorläufige Maßnahmen zur Verhinderung der Verbreitung von COVID-19, Fassung vom 15.04.2020. https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=Bundesnormen&Gesetzesnummer=20011076&FassungVom=2020-04-15

Burke, M., Hsiang, S. M., & Miguel, E. (2015) Global non-linear effect of temperature on economic production. *Nature, 527*. 235-239. DOI: 10.1038/nature15725.

CISA (2021) Identifying critical infrastructure during Covid-19. https://www.cisa.gov/identifying-critical-infrastructure-during-covid-19.

Dengler, C., & Lang, M. (2021) Commoning care: Feminist degrowth visions for a socio-ecological transformation. *Feminist Economics*. DOI: 10.1080/13545701.2021.1942511.

ETUC et al. (2007) Climate Change and employment: Impact on employment in the European Union-25 of climate change and CO_2 emission reduction measures by 2030.

http://www.unizar.es/gobierno/consejo_social/documents/070201ClimateChang-Employment.pdf.

Eurofound (2020) Sustainable work. www.eurofound.europa.eu/topic/sustainable-work.

European Commission (2019) *Employment and Social Developments in Europe, Review 2019. Sustainable growth for all: choices for the future of Social Europe*. DOI: 10.2767/305832.

European Commission (2020) Guidelines concerning the exercise of the free movement of workers during COVID-19 outbreak. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020XC0330(03).

European Commission (2021) EU Taxonomy, Corporate Sustainability Reporting, Sustainability Preferences and Fiduciary Duties: Directing finance towards the European Green Deal. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021DC0188&from=EN.

Fitzgerald, J. B., Jorgenson, A. K., & Clark, B. (2015) Energy Consumption and Working Hours: A Longitudinal Study of Developed and Developing Nations, 1990-2008. *Environmental Sociology, 1*(3). 213-223. DOI: 10.1080/ 23251042.2015.1046584.

Foster, K. (2017) Work ethic and degrowth in a changing Atlantic Canada. *Journal of Political Ecology, 24.* 633-643.

Frayne, D. (2015) Critiques of Work. In S. Edgell, H. Gottfried, & E. Granter (Eds.), *The SAGE Handbook of the Sociology of Work and Employment* (616-633). Los Angeles et al.: Sage Publications.

Frey, P. (2019) *The Ecological Limits of Work: on carbon emissions, carbon budgets and working time*. Autonomy Research. https://autonomy.work/portfolio/ecologicallimitscoverage/.

Garrett-Peltier, H. (2017) Green versus brown: Comparing the employment impacts of energy efficiency, renewable energy, and fossil fuels using an input-output model. *Economic Modelling, 61*. 439-447. DOI: 10.1016/j.econmod.2016.11.012.

GHK (2009) The Impacts of Climate Change on European Employment and Skills in the Short to Medium-Term: A Review of the Literature. https://ec.europa.eu/social/BlobServlet?docId=2863&langId=en.

Gorz, A. (1989) *Critique of Economic Reason*. London/New York: Verso.

Gorz, A. (1982) *Farewell to the Working Class. An essay on Post-Industrial Socialism*. London: Pluto Press.

Governo Italiano (2020) Decreto ministeriale 25 marzo 2020 – Nuovo Coronavirus. Modifiche al DPCM 22 marzo 2020. https://www.mise.gov.it/index.php/it/normativa/decreti-ministeriali/2040915-decreto-ministeriale- 25-marzo-2020-nuovo-coronavirus-modifiche-al-dpcm-22-marzo-2020.

Graeber, D. (2019) *Bullshit Jobs.* London: Penguin Books.

Hardt, L., Barret, J., Taylor, P. G., Foxon, T. J. (2020) Structural change for a post-growth economy: Investigating the relationship between embodied energy intensity and labour productivity. *Sustainability, 12*. DOI: 10.3390/su12030962.

Hardt, L., Barret, J., Taylor, P. G., Foxon, T. J. (2021) What structural change is needed for a post-growth economy: A framework of analysis and empirical evidence. *Ecological Economics, 179*. DOI: 10.1016/j.ecolecon.2020.106845

Hayden, A., & Shandra, J. M. (2009) Hours of Work and the Ecological Footprint of Nations: An Exploratory Analysis. *Local Environment, 14*(6). 575-600. DOI: 10.1080/13549830902904185.

Herzog, L., Sold, K., & Zimmermann, B. (forthcoming 2022) "Essential Work" – A category in the making? In L. Herzog, & B. Zimmermann (Eds)., *Shifting Categories of Work: (Un)Organized, (In)Visible, (In)Valuable.* London: Routledge.

Hoffmann, M. & Paulsen, R. (2020) Resolving the 'jobs-environment-dilemma'? The case for critiques of work in sustainability research. *Environmental Sociology, 6*(4). 343-354. DOI: 10.1080/23251042.2020.1790718.

Hoffmann, M. (forthcoming 2022) Sustainable Work: Foundations and Challenges. In L. Herzog, & B. Zimmermann (Eds)., *Shifting Categories of Work: (Un)Organized, (In)Visible, (In)Valuable.* London: Routledge.

Hyde, A., & Vachon, T. E. (2019) Running with or against the Treadmill? Labor Unions, Institutional Contexts, and Greenhouse Gas Emissions in a Comparative Perspective. *Environmental Sociology, 5*(3). 269-282. DOI: 10.1080/23251042.2018.1544107.

Illich, I. (1978) *The Right to Useful Unemployment and its professional enemies*. London/New York: Marion Boyars.

ILO (2012) *Working Towards Sustainable Development: Opportunities for Decent Work and Social Inclusion in a Green Economy*. Geneva: International Labour Office.

IPCC (2018) Mitigation Pathways Compatible with 1.5°C in the Context of Sustainable Development [Chapter 2]. In: *Global Warming of 1.5°C, Special Report.* https://www.ipcc.ch/sr15/.

IPCC (2021) Summary for Policymakers. In *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the IPCC*. Cambridge University Press.

Jackson, R. B., Friedlingstein, P., Andrew, R. M., Canadell, J. G., Le Quéré, C., & Peter, G. P. (2019) Persistent fossil fuel growth threatens the Paris Agreement and planetary health. *Environ. Res. Lett., 14*. DOI: 10.1088/1748-9326/ab57b3.

Johanisova, N. & Wolf, S. (2012) Economic democracy: A path for the future? *Futures, 44*(6). 562-570.

Kallis, G. (2011) In defence of degrowth. *Ecological Economics, 70*(5). 873-880. DOI: 10.1016/j.ecolecon.2010.12.007.

Kallis, G. (2013) Societal metabolism, working hours and degrowth: a comment on Sorman and Giampietro. *Journal of Cleaner Production, 38*. 94-98. DOI: 10.1016/j.jclepro.2012.06.015.

Knight, K. W., Rosa, E. A., & Schor, J. B. (2013) Could Working Less Reduce Pressures on the Environment? A Cross-National Panel Analysis of OECD Countries, 1970-2007. *Global Environmental Change, 23*. 691-700. DOI: 10.1016/j.gloenvcha.2013.02.017.

Larkin, A., Kuriakose, J., Sharmina, M., & Anderson, K. (2018) What if negative emission technologies fail at scale? Implications of the Paris Agreement for big emitting nations. *Climate Policy, 18*(6). 690-714. DOI: 10.1080/14693062.2017.1346498.

Latouche, S. (2009) *Farewell to Growth.* Cambridge: Polity Press.

Liebig, S. (2021) *Arbeitszeitverkürzung als Konvergenzpunkt? Sozial-ökologische Arbeitskonzepte, Wachstumskritik und gewerkschaftliche Tarifpolitik.* Frankfurt/New York: Campus.

Littig, B. (2018) Good work? Sustainable work and sustainable development: a critical gender perspective from the Global North. *Globalizations, 15*(4). 565-579, DOI: 10.1080/14747731.2018.1454676.

Mair, S., Druckman, A., & Jackson, T. (2020) A tale of two utopias: Work in a post-growth world. *Ecological Economics, 173*. DOI: 10.1016/j.ecolecon.2020.106653.

Malm, A. (2013) The Origins of Fossil Capital: From Water to Steam in the British Cotton Industry. *Historical Materialism, 21*(1). 15-68. DOI: 10.1163/1569206X-12341279.

Minx, J. C., Lamb, W. F., Callaghan, M. W., Fuss, S., Hilaire, J., Creutzig, F., Amann, Th., Beringer, T., Garcia, W. O., Hartmann, J., Khanna, T., Lenzi, D., Luderer, G., Nemet, G. F., Rogelj, J., Smith, P., Vicente, J. L., Wilcox, J., & del Mar Zamora Dominguez, M. (2018) Negative emissions—Part 1: Research landscape and synthesis. *Environ. Res. Lett., 13*. DOI: 10.1088/1748-9326/aabf9b.

Nabernegg, S., Bednar-Friedl, B., Muñoz, P., Titz, M., & Vogel, J. (2019) National policies for global emission reductions: Effectiveness of carbon emission reductions in international supply chains. *Ecological Economics, 158*. 146-157. DOI: 10.1016/j.ecolecon.2018.12.006.

Nässén, J., & Larsson, J. (2015) Would Shorter Working Time Reduce Greenhouse Gas Emissions? An Analysis of Time Use and Consumption in Swedish Households. *Environment and Planning C: Government and Policy, 33*(4). 726-745. DOI: 10.1068/c12239.

Nemet, G. F., Callaghan, M. W., Creutzig, F., Fuss, S., Hartmann, J., Hilaire, J., Lamb, W. F., Minx, J. C., Rogers, S., & Smith, P. (2018) Negative emissions—Part 3: Innovation and upscaling. *Environmental Research Letters, 13.* DOI: 10.1088/1748-9326/aabff4.

Rosemberg, A. (2010) Building a Just Transition: The linkages between climate change and employment. *International Journal of Labour Research, 2*(2). 125-161.

Rosnick, D., & Weisbrot, M. (2007) Are Shorter Work Hours Good for the Environment? A Comparison of U.S. And European Energy Consumption. *International Journal of Health Services, 37*(3). 405-417. DOI: 10.2190/D842-1505-1K86-9882.

Rübner Hansen, B. (2019) "Batshit jobs" – no-one should have to destroy the planet to make a living. OpenDemocracy UK. https://www.opendemocracy.net/en/opendemocracyuk/batshit-jobs-no-one-should-have-to-destroy-the-planet-to-make-a-living/.

Smetschka, B., Wiedenhofer, D., Egger, C., Haselsteiner, E., Moran, D., & Gaube, V. (2019) Time matters: The carbon footprint of everyday activities in Austria. *Ecological Economics, 164*. DOI: 10.1016/j.ecolecon.2019.106357.

Smith, K. R., Woodward. A., Lemke, B., Otto, M., Chang, C. J., Mance, A. A., Balmes, J., & Kjellstrom, T. (2016) The last Summer Olympics? Climate change, health, and work outdoors. *The Lancet, 388*. 642-644.

Snell, D. (2018) ‘Just transition’? Conceptual challenges meet stark reality in a ‘transitioning’ coal region in Australia. *Globalizations, 15*(4). 550-564. DOI: 10.1080/14747731.2018.1454679.

Sorman, A. H., & Giampietro, M. (2013) The energetic metabolism of societies and the degrowth paradigm: Analyzing biophysical constraints and realities. *Journal of Cleaner Production, 38*. 80-93. DOI: 10.1016/j.jclepro.2011.11.059.

Statistik Austria (2018a) Klassifikationsdatenbank Wirtschaftszweige: ÖNACE. http://www.statistik.at/KDBWeb/kdb.do?FAM=WZWEIG&&NAV=DE&&KDBtoken=null.

Statistik Austria (2018b) Table ‘Erwerbstätige nach ÖNACE-Branchen (1-, 2- und 3-Steller) für 2017’. Personal inquiry with Statistics Austria, November 2018.

Statistik Austria (2018c) Table ‘Luftemissionsrechnung 2008-2016: Ergebnisse für Wirtschaftsbereiche und private Haushalte’. https://www.statistik.at/web_de/statistiken/energie_umwelt_innovation_mobilitaet/energie_und_umwelt/umwelt/luftemissionsrechnung/index.html.

Statistik Austria (2018d) Physische Energieflussrechnungen (PEFA) 2016. https://www.statistik.at/web_de/statistiken/energie_umwelt_innovation_mobilitaet/energie_und_umwelt/energie/physische_energieflussrechnungen/index.html.

Steffen, W., Rockström, J., Richardson K., Lenton, T. M., Folke, C., Liverman, D., Summerhayes, C. P., Barnosky, A. D., Cornella, S. E., Crucifix, M., Donges, J. F., Fetzera, I., Lade, S. J., Schefferl, M., Winkelmann, R., & Schellnhuber, H. J. (2018) Trajectories of the Earth System in the Anthropocene. *PNAS, 115*(33). 8252-8259. DOI: 10.1073/pnas.1810141115.

Steininger, K. W., Lininger, C., Meyer, L. H., Muñoz, P., & Schinko, T. (2016) Multiple carbon accounting to support just and effective climate policies. *Nature Climate Change, 6*. 35-41. DOI: 10.1038/nclimate2867.

Steininger, K. W., Muñoz, P., Karstensen, J., Peters, G. P., Strohmaier, R., & Velázquez, E. (2018) Austria’s consumption-based greenhouse gas emissions: Identifying sectoral sources and destinations. *Global Environmental Change, 48*. 226-242. DOI: 10.1016/j.gloenvcha.2017.11.011.

Streicher, G., Kettner-Marx, C., Peneder, M., & Gabelberger, F. (2020) *Landkarte der “(De-)Karbonisierung” für den produzierenden Bereich in Österreich*. Wien: Österreichisches Institut für Wirtschaftsforschung (WIFO).

UNDP (2015) *Work for Human Development. Human Development Report 2015.* New York, NY: UNDP.

UNEP (2008) Green Jobs: Towards decent work in a sustainable, low-carbon world. www.unep.org/labour_environment/features/greenjobs.asp.

UNEP & Sustainlabour (2008) Climate Change, its Consequences on Employment and Trade Union Action. https://www.unep.org/resources/report/climate-change-its-consequences-employment-and-trade-union-action-training-manual.

UNFCCC (2015) Paris Agreement. https://unfccc.int/sites/default/files/english_paris_agreement.pdf.

US Department of Energy (2015) Innovating Clean Energy Technologies in Advanced Manufacturing. Technology Assessments, Chapter 6: Process Heating. *Quadrennial*

Technology Review. https://energy.gov/sites/prod/files/2016/06/f32/QTR2015-6I-Process-Heating.pdf.

Voswinkel, S. (2015) Sinnvolle Arbeit leisten – Arbeit sinnvoll leisten. *ARBEIT, 24*(1-2). 31-48. DOI: 10.1515/arbeit-2016-0004.

Watari, T., Nansai, K., Giurco, D., Nakajima, K., McLellan, B., & Helbig, C. (2020) Global metal use targets in line with climate goals. *Environ. Sci. Technol., 54*. 12476-12483. DOI: 10.1021/acs.est.0c02471.

Weeks, K. (2011). *The Problem with Work. Feminism, Marxism, Antiwork Politics, and Postwork Imaginaries*. Durham: Duke University Press.

FIGURES

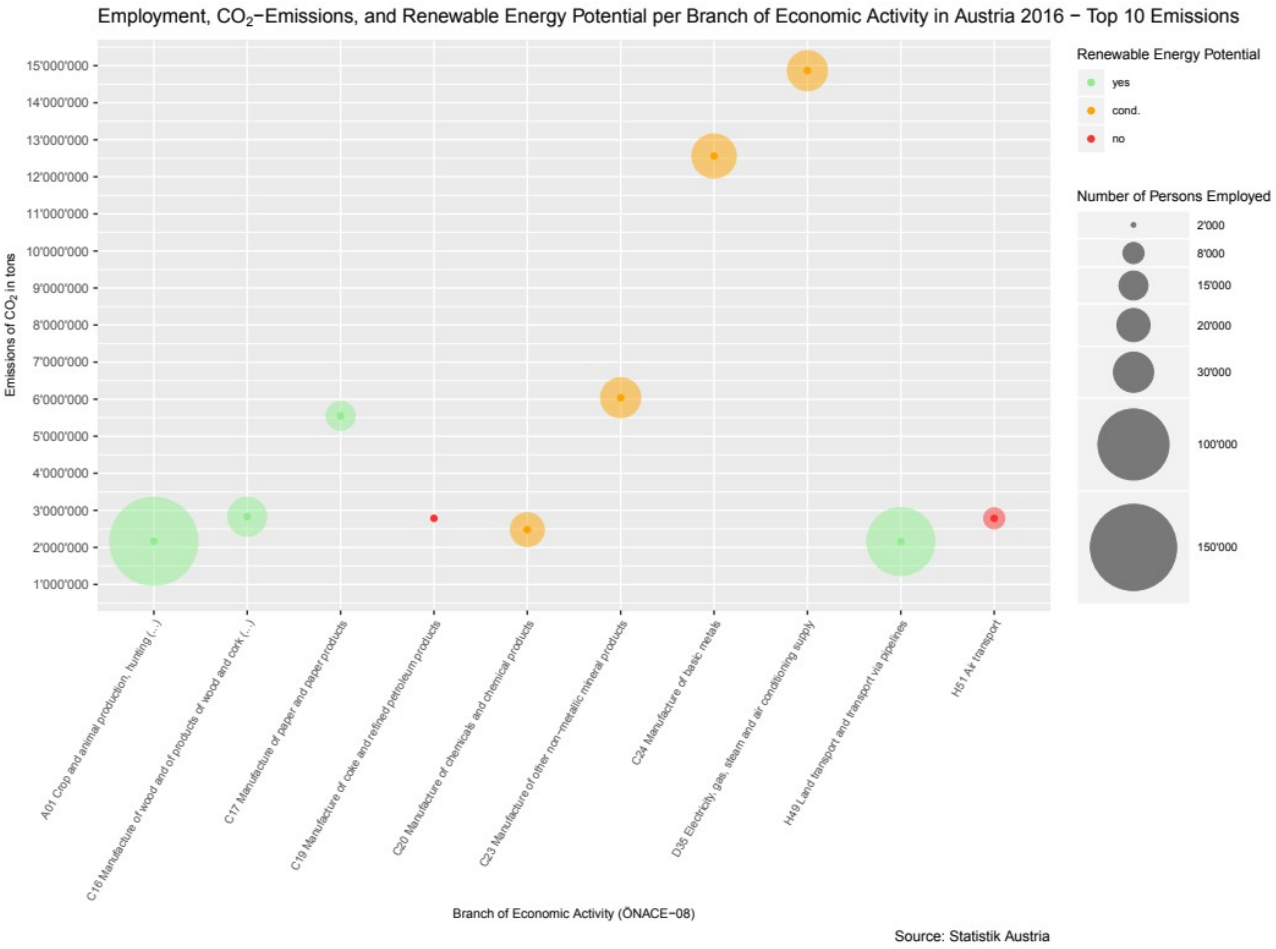
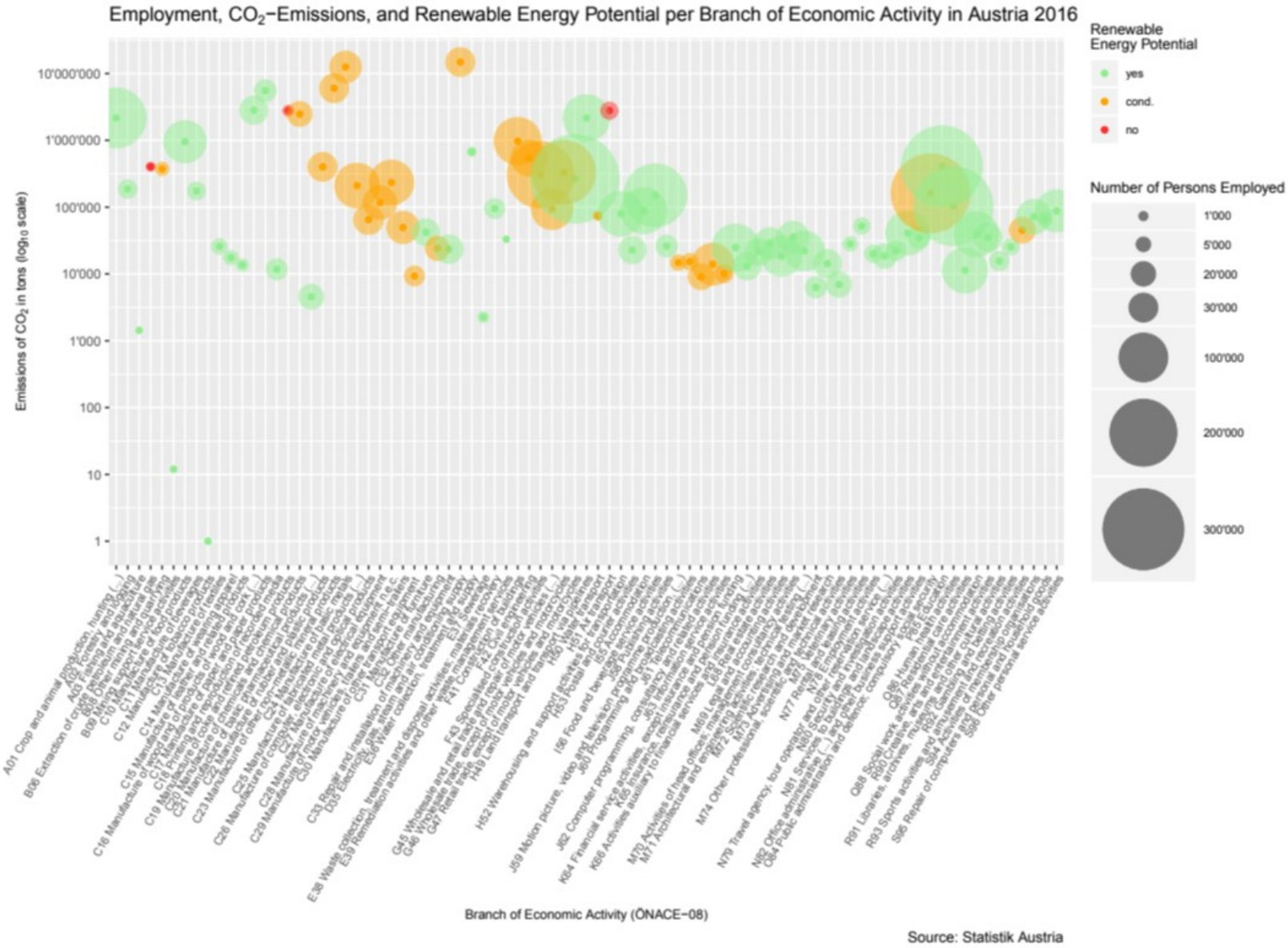


Figure 1: Employment, CO_2 Emissions, and Renewable Energy Potential per Branch of Economic Activity in Austria 2016 – Top ten emissions selection (figure courtesy of Johannes Handl)

On the following page:

Figure 2: Employment, CO_2 Emissions, and Renewable Energy Potential per Branch of Economic Activity in Austria 2016' – complete overview (kudos to Johannes Handl)


Employment, CO_2−Emissions, and Renewable Energy Potential per Branch of Economic Activity in Austria 2016
Emissions of CO_2 in tons (log_{10} scale)
10'000'000
1'000'000
100'000
10'000
1'000
100
10
1
Branch of Economic Activity (ÖNACE−08)
Renewable Energy Potential
yes
cond.
no
Number of Persons Employed
1'000
5'000
20'000
30'000
100'000
200'000
300'000
Source: Statistik Austria