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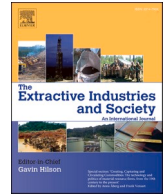
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Original article

Industrial workers' perceptions on just transition and work in four Finnish regions: Three-level solutions

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ABSTRACT

Just low-carbon transition raises pressing questions about the fate of workers in different industries and regions. Industrial decarbonization will influence job availability, quality, and regional economic structures even where industries are not foreseen to phase out. Yet, labour-oriented just transition studies have so far focused on fossil fuel industries neglecting other energy-intensive industries. This qualitative research article focuses on energy-intensive industries in four industrially significant localities in Finland. These industries are expected to undergo significant changes in their energy-intensive production processes. The article examines industrial workers' work and employment related perceptions concerning decarbonization, climate policies, and worker-level and regional capacities to transform vis-à-vis vulnerability under decarbonization. The findings reveal that just transition appears not only as a regional but also as an intra-factory and worker-level challenge, requiring comprehensive addressing by multiple actors. Differing regional characteristics and companies' decarbonization strategies link to different perceptions about transition prospects and related justice concerns. While some solutions suggested by workers are shared across all studied contexts, others relate to region- or industry-specific factors or socially vulnerable worker groups needing more support. The results also call for reassessing the relationship between public and private sector regarding their responsibilities for just transition.

1. Introduction

Energy-intensive industries play an essential role in emission reductions in low-carbon transitions. In 2019, the IPCC estimated industrial emissions to account directly for 24 %, indirectly 34 %, of global anthropogenic GHG emissions. Industrial emissions have grown the fastest among the emission-accounting sectors since 2000 (Bashmakov et al., 2022, 11) making their reduction critical for meeting the Paris Agreement goals and climate justice. Industrial decarbonization is increasingly critical since the global demand for many energy-intensively manufactured materials, such as steel, is foreseen to increase (Swennenhuis et al., 2022) due to the raw material demand implications of economic growth in many countries.

Pressures for industrial decarbonization, which have originated from both the EU and national climate policy choices, have generated public

and private initiatives and plans. Public initiatives vary from sector-wide plans, such as the European Commission's 'Green Deal Industrial Plan for the Net-Zero Age' (EC 2023), to energy efficiency and carbon pricing schemes. Technological decarbonizing solutions, such as electrification and green hydrogen, are promoted by public-private partnerships (Griffiths et al. 2021). The increased competitive advantage potential of carbon efficiency has encouraged company-led decarbonization of the manufacturing industry (Olatunji et al. 2019). Companies are increasingly placing their own GHG reduction targets (e.g., Net Zero Tracker 2022) driven also by various internal and external factors, including pressure from shareholders, regulations, cost savings, and even employees (Berger-Schmitz et al. 2023; Cadez et al. 2019; Dupuis and Schweizer 2019). The effectiveness of the targets and related action varies considerably among companies from symbolic statements to genuine climate leadership (e.g., Dupuis and Schweizer 2019).

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Just transition, justice in the planning, implementation and outcomes of climate measures, has become an essential demand for decarbonization. While economies evolve constantly, public policy initiated impacts are usually considered as relevant to justice (Kortetmäki and Järvelä 2021). Workers and other affected groups of people are potential ‘victims’ of injustices by decarbonization (e.g., Leino 2024). Key justice elements include just distribution of transition-related benefits and burdens, fair and participatory decision-making, and recognition of historically or socio-culturally created inequalities influencing how policies impact on different actors (McCauley and Heffron 2018; Wang and Lo 2021). Dealing with unavoidable trade-offs such as job losses from coal phase-out highlights restorative justice to compensate for harm (McCauley and Heffron 2018). While the scope of just transition is considerably broader than labour-focused questions, they remain central (Rosemberg 2010; ILO 2015; Morena et al. 2020). The widespread adoption of the objective of just transition into political agendas implies recognition that the impacts of low-carbon transition can be unequal and unjust. While the low-carbon transition may generate new employment nationally, this may not translate into tangible positive effects on labour demand, skills, and investment in vulnerable regions. Instead, local worker communities in energy-intensive industries may face significant employment challenges, with repercussions to workers’ families and public and private services in those regions. Just transition integrates these concerns into public climate policy (hereafter climate policy) and social policy agendas.

Due to the differentiated prospects of regional economies in the low-carbon transition, just transition research and initiatives involve a strong regional perspective. For example, the EU Just Transition Fund regulation links just transition to the EU cohesion and territorial development policy (EU 2021). Just transition involves regional development questions and the challenges of promoting sustainable development and ‘vitality’ outside growth regions (Donner-Amnell 2020). Tensions exist especially in natural resource-rich yet economically poor and politically relatively powerless regions (Halonen et al., 2022) whose vulnerability to economic disruptions is a pressing concern for just transition.

In this article, we address just transition in energy intensive industries focusing on industrial workers’ perspective. This is done in the context of Finland, in relatively peripheral regions and four energy intensive plants with high local socio-economic importance. We study industrial workers’ work and employment related perceptions concerning decarbonization, asking: How do industrial workers see the future of their regions and workers’ prospects in decarbonizing trajectories? How do the different perceptions about regional characteristics and vulnerability give rise to different solutions for realizing just transition? We address workers’ perceptions in four Finnish regions (described in Section 3.1) with big energy-intensive industries who have started to act upon the strong decarbonisation pressures.

Our study contributes to key gaps in just transition research. Scant yet emerging studies on energy-intensive industries (Antonazzo et al. 2021; Greco 2022; Swennenhuis et al., 2022; Zhu and Lo 2022) add important elements to just transition because manufacturing plant decarbonization differs from energy sector decarbonization: justice focus shifts from sectoral phase-out to job changes and the capacities and skills of workers (Greco 2022; Antonazzo et al. 2021). Transition impacts on regional economies remain a pressing issue (Swennenhuis et al., 2022; Greco 2022). By its regional outlook, our research contributes to the understanding of how to enable just industrial decarbonization and what factors are crucial in avoiding the “revenge of the

regions” or increased polarization in resource-rich regions like ones studied (see Section 2.1). These matters need attention to understand the regional dynamics of just transition outside coal regions. Within energy-intensive industry, just transition research in forest industry is still lacking. Forest industry¹ contributes to the diminishing of carbon stored in forests by logging and land use impacts, making its emissions relate both to energy-intensive industrial procedures and the obtaining of raw materials.

2. Background

2.1. Just transition as a challenge to regions and workers

Regional considerations matter to making low-carbon transitions effective and just. The socio-spatial embedding of sustainability transitions (Truffer et al., 2015) means that geographical differences (including institutional systems and networks) position actors differently regarding their capacities to engage in transitions. Regional characteristics and sub-/national public policies and institutional structures also lead to regionally different transition impacts (Häyrynen et al. 2023). Beyond spatial disparities, regional level matters because transition projects and related conflicts concretize at regional levels, (e.g., Kortelainen and Albrecht 2019; Leino 2024). While developed economies are better positioned to engage in transitions than exploited global South, justice requires attention to within-nation inequalities. Worsening existing disadvantages often manifests injustice even if the disadvantaged groups or regions reside in the globally better-off countries (Kortetmäki and Järvelä 2021). Even if global climate injustice is among the most pressing justice problems, the transition requires considering also other justice concerns related to climate actions and their repercussions.

Of particular concern are the futures of *peripheries*, areas rich in natural resources yet low in economic and political power (Halonen et al., 2022; Häyrynen et al. 2023). Rural peripheries and peripherally located industrial towns face numerous transition challenges: many such communities suffer from economic decline, which makes them less resourced to cope with societal changes (e.g. Häyrynen and Semi 2019). Some have become futureless, insignificant places (Rodriguez-Posé 2018). Powerlessness raises a question can peripheries influence in how the transitions are realized and governed: peripheries tend to lack control over the distribution of transition benefits and burdens (e.g., Halonen et al., 2022). Geographical isolation and low economic diversity may create high dependency on extractive industry as the provider of economic viability and workers’ income (e.g., Zhu and Lo 2022). Transition-supporting instruments might also maintain power structures and technological hegemony, ignoring regional alternatives and local community impacts (Häyrynen et al. 2023, 100).

Consequently, many natural resource-rich communities are vulnerable to regional injustices in the low-carbon transition. Social scientific climate change research often conceptualizes vulnerability as a function of exposure (to harm), sensitivity (to the effect caused by exposure), and adaptive capacity (to deal with the effects) (Adger et al. 2003; IPCC 2007; Kortetmäki and Järvelä 2021). Vulnerability has both physical and social aspects. Physical vulnerability concerns, for example, the material impacts of climate change on regions, systems (such as food systems), or people (Adger et al. 2003). Social vulnerability refers to the social/societal determinants of vulnerability, such as economic and policy impacts (Kortetmäki and Järvelä 2021), on regions, systems, or people. Here the vulnerability-focus is on social vulnerability. Both aspects are often connected: social vulnerability to climate policy, for

¹ Terms such as ‘forest sector’, ‘wood industry’, or ‘forest products industry’, or sometimes ‘forestry’, are also used around the world. We use ‘forest industry’ since it has become an established concept in Nordic discussions to distinguish the broad industrial sector from mere forestry as managing and using forests.

example, arises from the attempts to reduce the physical vulnerability to climate change related hazards. Because vulnerability is both ontological as an unavoidable condition and socially mediated as experienced by subjects in particular situations (Gilson 2024), revealing the socially mediated aspect of vulnerability requires addressing its manifestation in context-specific perceptions.

Regional decarbonization related vulnerabilities concern specifically regions reliant on carbon intensive industries and facing high unemployment. Addressing the differentiated regional vulnerability is suggested as important for regionally just transition (McDowall et al. 2023). Regional vulnerability to the low-carbon transition has been defined as the function of 1) the exposure of a region to likely job losses in carbon-intensive industries, 2) the sensitivity of the region to those job losses, and 3) the region's capacity to adapt its economy to decarbonization pathways (McDowall et al. 2023). Highlighting the gap between anticipated development and actual outcomes (Gilson 2024), vulnerability creates a temporal window for resistance and change that are central to negotiating transition-related justice (cf. Leino 2024).

Peripheries and industrial towns create various strategies to cope with the transitions. These vary from attempts to harness the promises of 'green economy' and attract investment money to more degenerative approaches, such as resistance to transition demands. The latter can lead to increased polarization and even 'the revenge of the places' meaning argumentative revolt against the political reforms (Rodriguez-Posé 2018; Häyrynen et al. 2023). Many subnational industrial regions may depend significantly on one industrial plant and the attached local industrial ecosystem (Fischer-Kowalski and Rotmans 2009; Talandier and Donsimoni 2022). Therefore, even the reduction of functions in the main local industry can have multiplied negative socio-economic impacts that are difficult to amend. Much depends, then on the regions capacities to adapt to the new demands and ability to decarbonize in ways that 'keep the economy going'.

Local capacity to decarbonization often depends on the ability to innovate and transform the existing industrial processes towards low-carbon solutions. In socio-technical research, such changes relate to material and technical factors (e.g., raw materials, transport, and communication infrastructure) and socio-cultural aspects (e.g., attitudes and understandings concerning local identities and the reshaping of cultural norms and rules) (Coenen et al. 2012; Geels et al. 2017; Hansen and Coenen 2015; Kivimaa 2021; Munro 2019). For example, place attachment and identities significantly influence community responses to transition policies (Devine-Wright 2013).

In peripheral regions, industrial workers' perceptions of key industries are usually deeply embedded in regional culture(s) shaping their attitudes towards present material (including employment and livelihood) circumstances and life prospects within the region (Horlings 2015; Byrne 2002). However, socio-technical path dependencies may also ground successful reform, if adapted appropriately (Sotarauta et al. 2023; Froy et al. 2023). This also depends on harnessing workers for the change. Although low carbon transition may reduce traditional employment, it is important that remaining workers in the region can perceive the place-based industries or, in case of their phase-out, the emerging alternatives as viable sources of local livelihood and security.

Alongside industrial workers' significance for the regionally successful decarbonization, their vulnerability to the low-carbon transition is a key concern (e.g., Evans and Phelan 2016; Greco 2022). Workers may remain vulnerable to changes even in regionally successful transitions and the vulnerability of workers is, thus, irreducible to regional vulnerability to low-carbon transitions. The EU Just Transition Fund JTF links both regional and workers' vulnerability explicitly to just transition. It aims '...to mitigate the adverse effects of the climate transition by supporting the most affected territories and workers' and '...pay special attention to vulnerable groups that suffer disproportionately from the adverse effects of the transition, such as workers with disabilities' (EU 2021). Workers' perceived vulnerability may also reduce support to changes in industrial transitions (Rosemberg 2010, 144).

Empirical studies are needed to understand the conditions under which local employees see industrial decarbonization as feasible and valued. Related to this, examining just transition from the perspective of vulnerability and analysing workers' perceptions is crucial. This research aims to increase understanding of how industrial workers perceive decarbonization in their regions. Workers' perspectives may diverge from those of their employers, who likely approach regions from a more global, business-oriented standpoint (Kentala-Lehtonen 2019; Vona 2019). Tensions emerge, for example, when industries fail to deliver the livelihood and regional development related promises, as has occurred in the Finnish peripheral manufacturing industry (e.g., Kortetmäki and Albrecht 2019). Including worker attitudes in regional and intra-factory transition planning and implementation contributes to just transition by increasing the perceived justice of the low-carbon transition in affected industries and regions.

2.2. Finnish manufacturing industry

Making sense of region-specific challenges for just industrial decarbonization requires knowing the basics of industrial developments constituting the current situation. In Finland, manufacturing industry has traditionally been spatially dispersed across the country. This owes to the dominance of forest industry. Around 1900–1950s, industrialization in Finland based mainly on lumber and later pulp and paper exports (Koponen and Saaritsa 2019). Relying on this structure, Finland's economy gradually became a successful small-state open economy (cf. Haaparanta et al. 2017). Spatially, the manufacturing industry organized and dispersed along the availability of the key natural resources. The second half of the 20th century witnessed rapid urbanization alongside diversifying manufacturing industry. Over time, many small industrial centres especially in the Northern and Eastern Finland became vulnerable to structural changes in the economy, leading to regional regression and peripheralization related to territorial deindustrialization (Tykkyläinen 2002; see also Makkonen et al. 2022).

Linked to the strong welfare state and comprehensive public sector in Finland (Halonen et al. 2015), a relatively strong public regional development policy has tried to balance this uneven economic development. This policy has been somewhat successful: many small industrial centres still operate and host a variety of manufacturing companies, though often with lower diversity of products and/or on a smaller scale than before. Finland's strong welfare state regime generally increases expectations for securing social justice in climate policy, and for social policies that alleviate and compensate climate policy harms (Kortetmäki and Järvelä 2021) such as reduced or heavily transformed local labour demand. Therefore, public coordination for decarbonization is expected to be relatively strong and include the social impacts of climate policy.

After ratifying the Paris Agreement (2016), Finland has performed, at least until the recent Government (2023-), relatively ambitious national climate policy and the state and big businesses have been well in tune in their climate policy ambitions (Huttunen et al. 2022; Kentala-Lehtonen 2019). For instance, steel industry, a major GHG emitter in Finland, is actively developing decarbonization solutions. However, the forest industry was not immediately targeted by climate policy and has instead increased wood procurement., which This causes controversy by reducing national carbon sinks that used to guarantee successful climate policy and reaching the national carbon targets (Sivonen and Syväterä 2022).

In Finland, private businesses have increasingly started to create climate strategies including decarbonization plans. These plans create needs for differently skilled workforce. To protect the opportunities of the current employees, the Finnish trade union movement has emphasised the importance of support for upskilling, reskilling, and education as central to just transition (SAK 2020). However, Finland and the EU (see Vandeplass et al., 2022) lack further specification of duties and contents of capacity-building for workers related to just industrial decarbonization.

Specification is also needed to understand the qualitative aspects of the regionally differentiated vulnerability outside coal regions, including understanding about labour substitutability (Vandeplass et al. 2022; Apostolopoulos et al. 2023). Therefore, we argue, it is important to examine empirically workers' perceptions on climate policy pressure on employment in energy intensive industries. Worker perspective is not meant to represent the views of the whole regional population. However, livelihood-related expectations of different local key actors need to conform reasonably to carry out orderly business. Hence, the overall successful evolution of industrial activities territorially is often a common interest among local key actors, especially if major socio-economic alternatives are not in immediate reach.

3. Data and methods

3.1. Studied regions and industry workers

Our study centres around four industrial towns residing in relatively peripheral locations. Their large, mainly export-oriented steel and forest industry plants are regionally significant wealth and employment opportunity creators and have even inter-/national economic relevance. They are also important to national climate policy success due to significant GHG emissions. The studied (semi-)peripheral areas lack industrial diversity or exemplify limited specialization in key industries and other local branches of economy and have, thus, remained without immediate benefits of agglomerating economies (Sotarauta et al. 2023; Bolter and Robey 2020).

Two of the large companies are active in the industrial forest sector, mainly pulp. Two operate in steel industry. Of the studied regions, Forest 1 represents a rather dispersed location in Central Finland, while Forest 2 resides in more urban-industrial South-East Finland region. Steel 1 resides at the fringes of peri-urban region near to a growing city, while Steel 2 is established in a major traditional industrial area in the North (Fig. 1).

3.2. Data collection

Our main interest was to understanding industrial workers' perceptions on the impacts of decarbonization in their regions and workplaces. Worker interests should not be equated to company interests: the two may parallel but also diverge as, for example, workers' critical remarks and livelihood leakage fears illustrate (see Results). Because our primary interest was in how industrial workers perceive the transition and how their perceptions differ between regions, we limited our scope to industrial workers. Studying generally local perceptions on transitions would have been a different task, which would not respond to our research questions. We do not assume that worker perspective represents all regional views.

Data collection was accomplished by workshops with blue- and white-collar workers of each large factory, and in the forestry locations also workers of smaller related (e.g., supplier/subcontracting) companies. We chose the studied regions and companies with the help of two

national confederations of trade unions: The Central Organisation of Finnish Trade Unions (SAK) and The Finnish Confederation of Professionals (STTK). Based on literature scoping and discussions with these organizations, the chosen areas were identified as places where low-carbon transition is expected to cause significant changes in employment with potentially regionally significant repercussions.

In summer 2023, we conducted one workshop in each studied region. In two large companies, the HR team provided us workers who participated in the workshops during their workday (management personnel did not participate in the workshops). Elsewhere, we reached participants with the help of the regional union organizers who gave insights on people to contact and circulated workshop invitations. The workshops were organized in the workplaces in Steel 1 and 2, in the municipal hall in Forest 1, and in a hotel in Forest 2. Participants were mainly middle-aged or younger, few were near retirement. The background information of participants ($N = 30$) is in Table 1.

In each workshop, we first introduced the purpose of the workshop and the research project. We also presented relevant results from a national survey on the public perceptions of employment and well-being effects of climate policies and policy preferences (AUTHOR-ANONYMISED) as discussion initiator. Personal data processing was explained and informed consent was obtained from all. Participants divided into two groups for actual workshop discussion (75 min) consisting of three themes: 1) decarbonization related changes in one's workplace; 2) regional prospects under decarbonization; and 3) skills development and participation opportunities in work. Researchers facilitated each group discussion. Discussions were recorded and transcribed. After the workshop series, we presented a general summary of findings to companies in a webinar (worker anonymity was protected, letting workers express critical views without the risk of disclosure).

3.3. Methods

Using mostly data-driven thematic content analysis, we coded the interviews inductively based on our research questions. We chose

Table 1
Background information of the workshop participants.

	Forest 1	Forest 2	Steel 1	Steel 2	Altogether
Participants	6	7	10	7	30
Gender					
Male	4	4	9	6	23
Female	2	3	1	1	7
Position					
Blue-collar worker	1	2	6	5	14
White-collar worker	3	2	4	0	9
(Workers, who were also union stewards)	0	0	0	5	5
Chief union steward	1	3	0	1	4
Regional union organizer not working in the plant	1	0	0	1	2



Fig. 1. Studied regions according to their basic characteristics.

content analysis over discourse analysis due to our interest in the ‘what’ and ‘how’ of worker perceptions rather than the ‘why’ of conveying views in particular ways. Content analysis, when data-driven, also lets the data speak and enables high sensitivity to informants’ perceptions. We adhered to interpretative subjectivism: we accepted all statements as relevant concerns and did not differentiate ‘unequal impacts that are with good reason concerns of justice from those impacts that may cause disappointment but are of lesser concern’ (Kortetmäki and Järvelä 2021, 221). Thus, our results are workers’ perceptions about justice-related concerns in a subjective sense, not necessarily concerns of justice in a theoretically objective sense.

The topics and related criteria for coding were the following: T1) *Regional and company prospects in decarbonization*: statements related to the regional future challenges and opportunities and related explanations; discussion about company-level transition strategies; discussion about the regional economy and development. T2) *Just transition related concerns*: calls for attention or worries that were linked to justice, fairness, disparities, or un/acceptability of solutions; related responsibilities; perceptions on employment and participatory opportunities. T3) *Skills development and worker capacities*: perceived education and skills development opportunities and barriers and impacts on future employment; perceived impacts of decarbonization on skill demands; knowledge on company-level decarbonization plans. We did test coding by several researchers to standardize coding procedures. After coding, we grouped the codes and summarized the first key findings

Next, we built region-specific profiles based on topic T1 and using theory-guided content analysis to understand and systematize the perceived determinants of regional vulnerability (see Section 5). To study justice concerns for regional transitions, we continued data-driven content analysis for the findings under topics T2 and T3. We paid particular attention to described territorial factors that were linked to various concerns and utilized the Atlas.ti software to investigate in-depth differences and similarities between the regions. To seek linkages between regional factors and justice concerns, we combined content analysis with code frequency and co-occurrence analysis at this stage. To study workers’ views on just transition solutions, we enriched content analysis with comparison to regional profiles to identify factors linked to certain types of solutions (see Fig. 2).

4. Results

4.1. Regional transition prospects and justice perceptions

Workers’ perceptions of the regional transition issues are summarized in Table 2 below. In what follows, we present detailed empirical results, first region-by-region regarding the perceived regional just transition prospects and concerns, followed by the possible solutions to the identified concerns. In Section 5, we discuss these results in the light of regional vulnerability and just transition to workers.

4.1.1. Forest 1

Regional transition prospects. Participants described the area as relatively peripheral forest-rural region where ‘money is tight’ for livelihoods. Natural forest resources were seen as crucial for livelihoods in the region directly and indirectly. Regional economic viability was understood to depend entirely on forestry that was perceived critical not only to this region but to the whole country:

‘Well, forest industry happens to be the big exports industry for us, from which we get money to this world, so if we think replacing that ... with like social services or some other jobs, well, our economy just doesn’t run that way.’ (Group 7, Informant P1)

The future of the key business actor (the forest industry group) seemed to determine regional prospects in the transition. The participants considered the continuity of currently good job availability as uncertain; positive regional development would require the continuing of large-scale forest industry. If climate policies restricted forestry significantly, this was perceived to generate a vicious circle reaching beyond the forest sector. Negative impacts were seen to hit raw material suppliers, but also to debilitate other livelihood sources and services by reducing purchasing power and municipal taxes. The vicious circle was seen to lead to the escape of those who can leave for better lives, population decline, and ‘regional death’. Participants also saw the location and forest sector as unattractive to younger generations, which the climate discussion aggravates: young people do not want to work in polluting industries.

Generally, the forest sector was seen capable of responding to some transition pressures, especially since it was perceived to perform already environmentally better than in other regions globally. However,

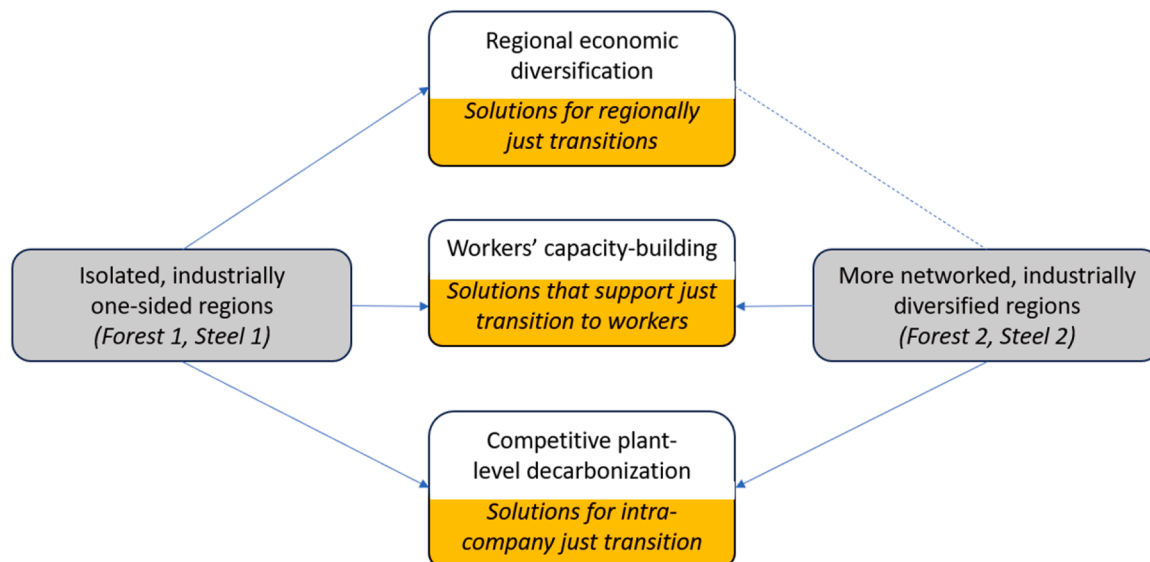


Fig. 2. Regional transition challenges and corresponding types of solutions needed for just transition. The dashed line between regional economic diversification and more networked, industrially diversified regions implies that in these regions this issue is already occurring and needs less attention.

Table 2
Summary of the just transition related regional questions as perceived by industrial workers.

	Forest 1	Forest 2	Steel 1	Steel 2
Regional transition questions	<ul style="list-style-type: none"> - Carbon and livelihoods leakage perceived as a real and unjust risk - Too rapid transition poses risks for livelihood losses - Production viewed as already quite sustainable, which is an asset while further improvement less so High regional dependence on forest industry causes vulnerability	<ul style="list-style-type: none"> - Regional mixed economy adds future opportunities - Geopolitics and markets more important change drivers than climate policies Regional diversification and development related to clean energy is an asset	<ul style="list-style-type: none"> - Strong trust in globally competitive factory transition - Market-based action is an asset (pioneering in fossil-free steel) High local dependence on a single large factory	<ul style="list-style-type: none"> - Regionally diverse large-scale industry seen financially strong and secured Regional diversification and development related to clean energy is an asset
Intra-company / worker specific transition questions	Particularly high burdens and losses to some families if they must move for a new job Workers' different skills development capacities and life-situations		High company-level preparedness is an asset Too high climate ambition of the state seen as unfair Equal opportunities for workers in the production changes	
	Unattractiveness of the region is a problem			

increasing demand for environmental sustainability from consumers was anticipated but participants also expressed doubt about whether decarbonization would still turn into a competitive advantage in global markets.

Regional transition-related justice concerns. The greatest worry for the participants was combined carbon and livelihoods leakage: the escape of industry outside Europe, which was seen to invalidate the mitigation gains from climate policies and cause severe socio-economic harms regionally.

“If the Finnish paper industry goes to South America, manufactures the paper or pulp there and brings it back to Europe, and eradicates Finnish and Nordic production and then we say that it all went well, we no longer have emissions or need to use forests.” (G7, P3)

Participants feared that national climate policies aiming at global pioneering cause unjust burden-sharing. The small nation and its workers were perceived to bear disproportionate costs of global climate actions without a difference-making global positive contribution. Pioneering was also seen to accelerate transition pace. This was regarded as risking justice since big industrial units are slow to transform and increasing risks for poorly managed transitions, with greater harms on employees and greater public costs. Participants also discussed the vulnerability of rural inhabitants, whose livelihoods rely on selling timber.

The differentiated skills development capacities of employees were seen to create injustices unless addressed. Especially older workers, lower-educated, and technologically lower-skilled workers were highlighted as groups vulnerable to job changes due to their lower capacities to up-/reskilling and task switching. If jobs are lost, the burdens of moving for a new job were seen greatly different. People with children and owner-occupied apartments would face much greater burdens due to the declined real estate values in selling the house in net emigration areas and socio-spatial losses affecting the whole family who must abandon place-tied arrangements for daily life.

4.1.2. Forest 2

Regional transition prospects. Participants described their location as an industrial locality in a geographically peripheral region (‘corner’) next to Russia. Regional economy was understood as heavily forest-based mixture with some steel industry and increasing activity related to clean technology (green hydrogen, synthetic fuels, renewables) the regional university has specialized in Forest and steel were identified as key regional industries whose prospects were seen to be determined by different factors. The participants saw the future of forest industry as

dependent on geopolitics and markets. Geopolitics was described to influence the availability of natural resources previously obtained largely from Russia which was stopped due to Russia’s invasion of Ukraine. The scarcity of raw material was seen to potentially create a regional ‘play-off’: forest sector will not vanish, but some production units will. Climate policy, however, was seen as unrelated to this.

‘Shutdowns are not caused by climate change or anything, it is just money. It is the economy, there is nothing else in that.’ (G2, P3)

The participants described that geopolitical reasons had fostered local energy transition. Stopping gas imports from Russia gave momentum to the clean technology related research and innovation, aiming at creating a ‘Hydrogen Valley’ where the regional university was seen as central. These trajectories influenced the perceived future of the local steel and forest industry, too. Opportunities with clean energy were seen positively and pioneering in their adoption perceived as an international competitive advantage. Collaboration with the university was seen crucial for innovating and assessing the feasibility of new solutions.

Overall, regional prospects were perceived to be minimally harmed by climate policies. However, the unattractiveness of the region was seen as a threat. Regional population has fallen steadily during the last two decades and is expected to decline by 13 % by 2040, mostly among the working-aged and younger (OSF 2021). The participants described how one solution, increasing the share of foreign workers, was perceived to create challenges in communication and training, risking the emergence of two-tier labour markets where foreign workers are employed to meet the labour demand yet with impoverished job conditions and/or payment (decreased job quality).

Regional transition-related justice concerns. The general perception about regional justice in decarbonization in the region appears very different from the region Forest 1. Decarbonization was seen as driven by market-based factors and the scope of justice in discussions was narrower. Market-based changes and geopolitical events appeared as response-requiring realities rather than particularly just/unjust events. Market-driven demand for decarbonization was seen to reduce the fear of carbon and livelihoods leakage. The nurturing of research, innovation, and activities around new business opportunities in clean technology was associated with positive regional opportunities. Positive future expectations were expressed also by people who did not expect direct benefit from these activities.

Differentiated capacities of workers raised concerns for social justice especially if having a job or retaining the similar kind of job would require moving elsewhere and the topic was most emphasized in this region. Higher age was seen to create challenges, especially regarding skills development and the soon-retiring people were hoping to avoid

demands for reskilling or upskilling, which they viewed as imposing greater relative burdens.

4.1.3. Steel 1

Regional transition prospects. The participants defined the area as a small industrial town located in the southern periphery of Northern Ostrobothnia, relatively close to the urban energy-intensive industrial region in the province. Peripheral features of the locality were noted as the absence of services and education opportunities (and net emigration). The Northern location and industrial characteristics were juxtaposed against the south: in the North, the realities of life were seen as different from those in Southern Finland, an issue perceived as not always understood by people living in the South and policymakers therein.

The local role of the steel plant directly and indirectly (via supplier networks) was seen to be huge. If the plant closed, the entire municipality would basically cease to exist:

‘If the steel industry ended here, I’d say it will take no more than a decade when the flags are flying at half-mast and graveyards filled with those who stayed’ (G6, P1)

To secure its future existence, the company had already made large-scale investments in creating a new fossil-free steel production process (yet in the making). Demands for fossil-free steel were described to originate equally, or more, from markets than from public policies. According to the participants, the big investment, ‘a brave decision’, implies pioneership frequently equated with competitive advantage and international success that was seen to create regional wellbeing. Additionally, the ‘never-ending’ demand for steel as a product nurtured overall sense of security regarding the availability of steel-related jobs in the region in the future. Attitudes regarding low-carbon transition had also been noted as shifting to more transition-supportive in the last few years.

Regional transition-related justice concerns. Participants quite broadly agreed that plant-level transformations help the company secure success in international markets as interest in low-carbon and fossil-free steel has increased. The chosen transition pathway was seen more as a necessity than as a question of un/just climate policies. The regional industry was already seen as proceeding with significant pace towards decarbonization. The participants compared the changes with longer historical trajectories: tasks in the plant have always changed and created reskilling demands.

Intra-factory just transition was a concern, however. The timing and details for plant-level changes were still uncertain. How the switch happens was critical for the local worker experience about un/just transition. Justice was understood to depend on who benefit from jobs created by the new fossil-free process and what happens to former workers when the switch, eventually, leads to old unit closure. Moreover, the participants worried that fluctuations in the number of employees in different stages of the switch might create municipal governance challenges.

The differentiated capacities of people for retraining and moving were demanded attention, similarly to the Forest regions. Especially older workers were seen as vulnerable to changing demands in work. Moreover, the participants highlighted that families should be considered as the basic unit of concern in just industrial transition. Differentiated life situations were also seen to help create diversified solutions for justice. The number of soon-retiring people could help ‘smoothen’ the transition especially in stages involving job declines. Younger people with little place-based ties might happily migrate for new attractive opportunities, which was also seen to diversify the available solutions for employees who strongly prefer staying.

Criticism towards the national climate policies revealed suspects and feelings of injustice related to disproportionate burden-sharing adopted

deliberately by the state itself if the small nation tries to be a forerunner globally. Pioneering in climate action was considered as too risky and burdensome relative to the contribution a small country can make. Since the state was also held as responsible for climate policy impacts, it was suggested that ambitious public policy driven decarbonization could reduce public finances and therefore limit the welfare state’s resources in alleviating social impacts of decarbonization.

4.1.4. Steel 2

Regional transition prospects. The area was defined as a northern net emigration region with low-educated population and that belongs to the main heavy/large-scale industry exporting region in Finland. The region was characterized as ‘the moneymaker for the whole country’, due to which the overall situation for future economy and livelihoods was perceived regionally secured and positive even despite a recent single (forestry) plant closure.

‘Regarding this economic region, I see it very viable still in 10, 15 years ahead. ... circular economy and thereby environmental technology development, our future here will in some way be basically built on those in this region, and side streams’ (G3, P1)

New opportunities were perceived to exist especially around bio-economy and circular economy, which was understood as positive for networking and collaboration between companies in the region. Overall, green transition was perceived to increase the demand for workers in the region and enable economic viability in the future. At the company level, climate actions were seen as the condition of future existence. This also generated generally positive attitudes towards various future investments, which were also linked to the export potential.

Green steel was seen to have future, and the ability of the local industry to meet those expectations was perceived good. There was no general belief that the steel industry activities would stop in the region, so there was a remarkable overall faith in job security. If the steel industry was stopped, however, from the workers’ perspective that would create a ‘local end of the world’ because the direct and indirect impacts of a single employer are significant especially in the given municipality and its neighbouring towns.

Regional transition-related justice concerns. The state-level carbon neutrality 2035 target was seen to set too rapid transition demands for large energy-intensive industry. Heading towards decarbonization was seen right but the pace wrong. Criticism of being ‘too fore among the forerunners’ was notable, combined with the perception of disproportionate burden-sharing. In addition, concerns about social inequalities at the national level, especially regarding the social vulnerability of lower-income people to rising costs of living and consumption, were raised.

Despite concerns about the pace, regional prospects in decarbonization were seen mainly positively. The regional diversity of exporting industry was seen to secure employment opportunities in the future, even if transition meant job losses in single plants. Some participants raised, nevertheless, uncertainty about whether and how the decarbonization-related future opportunities can be harnessed.

Intra-company transition impacts were foreseen unjust for some workers. Company-level climate actions were considered as potentially creating fears of losing one’s job, especially among rank-and-file workers with less knowledge about the company strategy. The differentiated capacities of workers were also called consideration. Lower-educated and older workers were seen as more vulnerable to injustices due to lower reskilling capacities and more difficulties in seeking job elsewhere. Equal possibilities to retain current socio-spatial patterns of living and working were seen important, implying strong socio-spatial embeddedness or place attachment. The participants had some concerns about the deterioration of working conditions and decreased job quality, especially in a situation of sudden increase in labour

recruitment and simultaneous outmigration of young people from the region. Concerns related to the readiness of companies to successfully invest in integrating new staff, including eventual immigrant workers, to the working community.

4.2. Making the transition more just: similarities and differences between regions

The regional analysis demonstrated how injustices and positive opportunities created by transition exist in relation to regional, intra-company and worker specific factors. Strong interaction occurs especially among the intra-company and worker-specific factors. Next, we outline the workers' solutions for alleviating these injustices.

4.2.1. Solutions for regionally just transitions

Some of the solutions for regionally just transitions applied to all regions. State was seen responsible for alleviating socio-economic harms from climate policies generally, which were believed to emerge regardless of state investments in RDI (research, development and innovation) that could be considered as having supported transition preparedness of companies for long. Companies were seen as responsible for their current workforce and workers' opportunities to either continue in their jobs, switch jobs inside the company, or get retraining for a new job. However, a key finding is that decarbonization via market mechanisms (market-demand for cleaner production) was seen to reduce the need for public actions for regionally just transition. When industrial decarbonization measures were perceived to secure competitiveness in the international markets over time, anticipated changes were expected to yield more benefits than burdens, contributing to the stability of regional livelihoods. Market-driven transitions were also seen to shift some responsibility from the public sector to companies. Sufficient transition periods and predictability were regarded as important for justice: rapid or unexpected transition demands were feared to increase the risk of regional failures in the implementation of transition actions and, consequently, job losses. Sufficient transition periods were also seen more just by decreasing the need to use public money for supporting companies in transitions. However, perceptions about the appropriate pace varied.

Participants' region-specific solutions for increasing or ensuring justice in the industrial decarbonization depended on regional features. In regions depending on a single industrial actor, alleviating the risks and fears of carbon and livelihoods leakage was seen as crucial for justice. Furthermore, communicating the positive regional opportunities from decarbonization, if found credible, may improve experienced justice by reducing the fear of regional disadvantage due to decarbonization.

Because participants associated regional economic diversity with more secured regional employment prospects and improved opportunities (rather than threats) from the transition, regional economic diversification may help make transition-related changes and uncertainties appear as more just. However, among the rank-and-file workers climate action related changes in the workplace might nurture fears of job losses even in the cases of generally positive regional impacts. These need separate addressing at the intra-factory level.

If job losses realized, workers highlighted the need for life situation sensitive solutions, especially if some need to move for a new job. Protecting the possibility to find meaningful employment without moving is particularly important for families with children and housing property in net emigration areas. Economic losses from having to sell a house in a net emigration area might generate expectations for compensation if moving is practically demanded by climate policy impacts. Ordinary or early-age retirement was seen as a good means to smoothen the harms from job losses. Early retirement plans were perceived to support locally just transitions as they also help soon-retiring people avoid burdening reskilling demands.

4.2.2. Solutions for just transition to workers

From the worker perspective, the key issues involved attention to skills development. Multiskilling was already encouraged in many places and the workers regarded it as a good strategy. Most participants were very positive about learning new skills to enable working in different tasks in the company. Due to the constraints and difficulties of individual employees, state and employer-based support for education and skills development opportunities was generally regarded as necessary.

When workers feel being blamed by the public climate discussion, intra-company knowledge dissemination was perceived important for alleviating the sense of unjust transition demands. Improved knowledge about company's emissions and reasons for emission reductions were seen as important for transition acceptance. Knowledge dissemination and communication may also help reduce workers' concerns about the future skills demands and the future of the entire industry. Such concerns were present in both industries but weightier in the forest industry.

Large-scale production line/unit replacements for decarbonization were seen to create intra-factory winners and losers. 'Forgetting/leaving' former workers to the unit that is later closed was considered as very unjust, implying that the company is expected to invest in the reskilling of existing workers even if labour markets had available already skilled workforce for those tasks. Employers were seen responsible for education and skills development in intra-factory transitions that change job descriptions.

Formal on-site education or retraining was seen to improve workers' adaptive capacities in several ways. Some plants used apprenticeship to get new motivated workers. This was seen to enable people to qualify for jobs they lack formal training for and would also help current workers to switch tasks. Apprenticeship was also appreciated for getting formal recognition of the skills learnt while working at the company, which improves the opportunities of getting a similar job elsewhere.

However, the differentiated capacities of workers need consideration for designing intra-factory just transition. If job descriptions change, workers' barriers to skills development need action. Participants pointed out that learning a new occupation or skills via formal education may be hampered for economic reasons, demands of shift work, age, or family situation. Except for age, these barriers can be addressed with proper support. Older and/or lower-skilled workers were perceived as particularly vulnerable to falling behind and the opportunity of older workers to round off their career without significant retraining should be supported. Participants also observed that certain tasks may be too demanding for some: digitalized jobs with constant upskilling are not for everyone. Having less demanding work opportunities was regarded as necessary for justice.

Connections between different regional transition opportunities and related justice challenges are shown in Fig. 2. In all categories, many solutions either require or are more likely to realize with supportive sub-/national public policies such as just transition funds. However, this policy dependence was not highlighted by informants.

5. Discussion

Next, we discuss the implications of our findings in the light of regional vulnerability and intra-factory, worker-related findings. We also reflect our results against previous research. Differences in the perceived regional vulnerability to industrial decarbonization engendered partly differing perceptions on region- and industry-specific just transition concerns and solutions. Just transition to workers, in turn, highlights the responsibility of companies for just transitions.

5.1. Regional vulnerability to decarbonization: learning from the worker perspective

We maintain that just transition benefits from addressing regional vulnerability to the impacts of decarbonization. Our results add

qualitative nuance to studies on regional vulnerability to low-carbon transition (e.g. McDowall et al. 2023). This is important for recognition justice by making the local communities and vulnerable groups visible to transition decision-making (Leino 2024). From the workers' perspective, the *exposure* element of vulnerability relates to global market responses to climate policies and their implications on regional economies. *Sensitivity* is understood through the transition impacts on labour markets, employment insecurity, and regional dependency on energy intensive production. Expectations for adequate *local adaptation* and community response to risk vary from high-level anticipatory reforms to a sense of helplessness, reflecting different peripheral strategies to sustainability transition pressures (Rodríguez-Posé 2018; Häyrynen et al. 2023).

Regarding *exposure*, industrial workers perceived decarbonization as ongoing in the EU but not necessarily globally: exposure is globally disproportionate. Under the intensive global competition of energy-intensive big industries, plants may be moved due to competitiveness-influencing factors such as decarbonization (Åhman et al. 2017). The need to prevent carbon and livelihoods leakage (cf. Bell et al. 2023 on defence industry) was seen as the responsibility of public actors. Workers suspected that the Finnish decarbonization pace endangers the global competitiveness of domestic industries. This repeats earlier findings about transition pace related concerns (e.g., Apostolopoulos et al. 2023; Lempinen and Vainio 2023). For a country whose wealth has been largely built on exports, such policies may be perceived unjust as almost self-destructive. These reasons might explain why market-driven decarbonization pressures were generally perceived to raise less justice concerns than public-driven decarbonization: market-driven transition does not feed leakage but encourages companies to maintain production within the decarbonizing regions.

Perceived *sensitivity* to transition impacts depends on spatio-economic factors. Isolated location and economic one-sidedness were associated with higher sensitivity. Regional economies that rely heavily on low-degree processing forest industry (requiring large-scale crude resource utilization) were seen as particularly sensitive to climate policies. The identified aim of resource-rich forest peripheries at 'super-productivist' bioeconomy strategies (Häyrynen et al. 2023) may accentuate their sensitivity. Preventing peripheries from being left behind was seen to require region-specific solutions. These can arise from historical developments, as differences between Forest 1 and Forest 2 showed. Forest 2 region had been more sensitive to geopolitical developments due to its close location to the Russian border (implying previously active raw material acquisition from Russia). However, the same factor seems to make Forest 2 perceived as less sensitive to climate policy developments. This is because in Forest 2 region, actors have already been forced to diversify their business strategies for other than decarbonization reasons.

Transition perceptions also depend on whether the 'emission problem' is primarily with raw materials (forest industry), implying the risk of production unit closure, or the industrial process (steel). Main proposed responses to reduce sensitivity are regional diversification based on the existing capacities and development paths (Froy et al. 2023) and competitive decarbonization in the large plants. Of studied regions, Steel 1 was planning competitive decarbonization, Steel 2 relied on both strategies, Forest 2 diversification, and Forest 1 was still mainly depicted as highly sensitive, perhaps related to its recent failures to meet the promises of regional development (Kortelainen and Albrecht 2019). Different coping strategies engender various ways of reorganizing employment under decarbonization (cf. While and Eadson 2022; Swennenhuis et al. 2022). While steel decarbonization strategies have been suggested to imply plant relocation risks (Swennenhuis et al. 2022), our findings did not show this concern but competitive decarbonization was perceived to support regional business continuity.

Regional and local capacities to adaptation vary remarkably across regions and plants. Regionally high adaptive capacity perceptions were associated with utilizing forerunner technologies or nurturing RDI to

diversify regional economy and create benefit from decarbonization more broadly. In some regions, workers perceived the region as mainly trying to secure existence, others were seen to benefit from the decarbonization pressures by investing in new clean technology RDI and business operations. While regional adaptive capacities also depend on national policies and opportunities therefrom (e.g., Lempinen and Vainio 2023), differences observed in our study related much to factors independent of sub-/national public policies. Recent research has suggested that vulnerabilities in staples-dependent economies (like forest industry) present opportunities for unlocking 'beyond-staples' capacities to create bottom-up approaches to regional economic development (Darko and Halseth 2023). Our study suggests that Forest 2 had succeeded in unlocking some of such capacities, compared to Forest 1 located in a region with lesser RDI and technology utilisation related economic diversity. This suggests that different regional strategies may enable or hinder the harnessing of latent capacities but further studies on realizing bottom-up approaches are needed and should address the barriers that the peripheral location of decarbonizing plants are seen to create to attracting new workforce (cf. Kortelainen and Albrecht 2019). Findings suggests the need to consider regional adaptive opportunities more holistically than in terms of job opportunities. Häyrynen et al. (2023) see the latter viewpoint as the risk of 'bioeconomy' rhetoric: equating justice in transitions to jobs and other quantitative indicators while disregarding critical qualitative factors such as economic diversification, social capital, and regional attractiveness. Further research is needed to understand how the holistic evaluation could incorporate the vulnerability perspective, social capital, and regional well-being, and help resolve the identified challenges.

Addressing the diverse concerns for just industrial transition benefits from sharing the views of workers with the employers and policy authorities. It is important to identify prevailing path dependencies, eventual innovations (Rypestol et al. 2022), and regional factors that influence how vulnerability manifests locally, yet also identify skills and resources that could ground diversification into related green activities (Froy et al. 2023). Just transition makes a test for available local partnerships and sub-/national decision-makers who can be identified as responsible for regionally just transition (c.f. Tie and Zhu 2022). Our findings also call for revising this understanding of just transition roles and responsibilities: perceived responsibility may in certain transition pathways fall more on private sector, challenging the conventional perceptions of public sector as the primary enactor of justice. This can mean, for example, requiring companies to adopt more proactive transition strategies and thereby foster capacity building for making transition demands a competitive asset rather than a problem. The role of companies as redistributors in just transition, suggested in literature (Kortetmäki and Huttunen, 2022), also raises justice questions regarding who will pay for the carbon sink losses caused by the forest industry. Nuancing private sector actors' responsibilities for just transitions will require further research but one related point became already well elaborated in our research: companies are seen to have diverse just transition responsibilities towards their workers.

5.2. Just transition to workers: intra-factory and socio-spatial issues

Industrial workers may face uncertainties and injustices both for regional reasons and due to intra-factory transition strategy and management. Even if the regional vitality retains or improves in the transition, some worker groups might be hit hard due to the various geographies of decarbonization (While and Eadson 2022) and skill gaps between old and new jobs (Greenspon and Raimi 2024), among other factors. Similarly, intra-factory transitions may support business continuity yet leave some workers much worse off (cf. Zhu and Lo 2022; Swennenhuis et al. 2022). Responsibilities for preventing such transition injustices were largely perceived to fall on the companies themselves, implying the function of companies as rights protectors, distribution balancers, and capacity builders for realizing justice in low-carbon

transitions (cf. Kortetmäki and Huttunen 2022).

Changes in *employment and job descriptions*, while partly perceived as normal business development, may be felt unjust to vulnerable groups. Older workers and low-/unskilled workers were identified as particularly vulnerable. Both groups are known to be vulnerable to economic restructuring processes (e.g., Rypestol et al. 2022), including low-carbon transitions (e.g., Evans and Phelan 2016; Apostolopoulos et al. 2023). Improved opportunities for skills development and formal education for new occupations can strengthen workers' resilience amidst changes and uncertainties, especially for low-/unskilled workers. Similarly to fossil fuel workers (e.g., Greenspon and Raimi 2024), just transition to industrial workers in our understanding requires place-based capacity-building. For older workers, the brevity of the remaining career makes reskilling have lower, uncertain return of investment. Participants also highlighted that not everyone is able to engage in higher-end jobs and skilling demands. A just transition, workers suggested, should preserve working opportunities also for the 'low-tech workers'. Overall, skills development discussions highlighted the responsibilities of companies towards their current workers but also soon-retiring workers, not leaving them behind.

Socio-spatial embeddedness emerged especially in discussions about labour mobility. Local embeddedness has traditionally been often perceived as resource for the social solidness of the industrial community. We did not perceive as strong socio-cultural ties with job identities as have been found in coal communities (e.g., Cha, 2020; MacNeil and Beauman, 2022) and energy peat industry (Lempinen and Vainio, 2023). Decarbonization related labour market restructuring may, nevertheless, imply greater mobility demands than workers are ready to take due to their socio-spatially embedded identities. Workers often found the possibility to continue life in familiar communities with existing social networks important. This kind of place attachment resembles the findings of Zhu and Lo (2022) where keeping the same workplace, working community, and living place were seen as more important than work contents. Retired people were also often willing to stay in the region. However, some people perceived moving as opening new opportunities and life improvement. Consequently, our participants emphasized that handling job relocation requires life situation sensitive solutions where family constitutes the basic unit of consideration.

Our research has three limitations. First, well-aware, interested employees are probably overrepresented in our data: in most companies, participants had to invest their free time to join our workshop. A large share of participants were union stewards with a special occupational status. Yet, if union stewards know the 'common concerns' in their workplace, this enriches data. We were concerned yet did not find signs of union stewards articulating particularly 'pro-company' interests or company advocacy more than other informants. Second, regional settings feature local peculiarities limiting the generalizability of findings, and related data considerations have been discussed earlier in this article. However, we believe that our results are grounded in sufficiently general regional and industrial features to bear relevance for industrial just transition studies in global North. Finally, our focus in Finland illustrates injustices in high-income countries. However, we acknowledge that just industrial transition in global perspective faces severe problems lacking from our study, threatening human rights and national sovereignty (e.g. Swilling 2020). Many industrial operators also have global supply chains bearing justice impacts on global scales. These remarks call for further research to compare the perceptions between different scales.

6. Conclusion

We studied workers' perceptions in energy-intensive industries on decarbonization prospects and on just transition both regionally and at factory-level. Regional differences influence the perceptions and expectations about the opportunities and risks brought forward by the low-carbon transition. Uncertainties accentuate the perceived regional and

factory-level vulnerability to industrial decarbonization, highlighting various concerns of justice. If the region or the large company is perceived to face more opportunities than threats, general perceptions on the transition are significantly more positive also regarding justice.

Positive opportunities can appear in regional and intra-company level. Regionally, sufficient economic diversity and innovation and collaboration around clean technology or related solutions were perceived to improve job availability and business opportunities, making the region a likely winner in the low-carbon transition. At the company level, those who viewed low-carbon transition as driven by market demand rather than public climate policies also considered company-level decarbonization as supportive to its competitiveness. In that case, justice questions associated with intra-company decarbonization become highlighted. Our findings suggest that market-driven decarbonization in energy-intensive industries may be perceived more just than policy-driven transition.

Concerns and solutions for just transition also depend on the transition-driving forces and whether changes are considered as primarily regional or intra-factory. Regionally, the biggest concern especially for one-sided forest regions is carbon and livelihoods leakage. Ensuring that decarbonizing companies can retain their international competitiveness was considered as critical for just transition. Increasing business activities, research, and innovation around decarbonization were perceived as reducing regional vulnerability to decarbonization. In steel industry, trust for global competitiveness of fossil-free steel was notably higher and intra-factory management more focal in just transition.

The question of just treatment of workers with different life situations and capacities is central in the intra-factory transition. Companies were seen responsible for supporting the skills development of their workforce, while individually differentiated barriers to re-/upskilling need also public policies. Successful intra-factory transition might create job losses by overall decline in labour demand or by fluctuations caused by process technology switches. Participants saw that prioritizing current workers and enabling them to benefit from the new opportunities is central to justice. The vulnerability of older and lower-educated workers was highlighted. Other broadly shared concerns regarded differentiated losses related to having to move for a new job, accentuating state-level responsibilities for seeking solutions to alleviate or compensate such losses.

Overall, transition-induced demands and repercussions are loaded with social justice concerns. They manifest both at the regional and intra-factory level and call attention for the creation of new local and sub-national partnerships and the seeking of measures that reduce regional vulnerability to low-carbon transitions and improve workers' resilience to changes brought about by industrial decarbonization. In energy-intensive industries that are not foreseen to phase out, future studies are needed especially to understand better the roles of both public and private actors in supporting just industrial transitions.

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CRedit authorship contribution statement

Teea Kortetmäki: Conceptualization, Investigation, Methodology, Writing – original draft. **Suvi Huttunen:** Conceptualization, Investigation, Writing – original draft. **Marja Järvelä:** Conceptualization, Methodology, Writing – original draft. **Anni Turunen:** Investigation, Writing – original draft.

Declaration of competing interest

The authors have no competing interests to declare.

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