# 1 Introduction

## 1.1 Disrupting technologies?

The title of this thesis contains an ambiguous phrase: “Disrupting technologies”. Does the gerund mean to say that technologies are causing a disruption or technologies are being disrupted? The expectations that technologies disrupt the status quo have pervaded the contemporary technological imaginary.[[1]](#footnote-2) Climate change mitigation policies are no exception. The cornerstone tenet of the UN Framework Convention on Climate Change, instituted in the Kyoto Protocol, is that climate protection can be achieved through the process of ecological modernisation (Bäckstrand and Lövbrand 2007). Ecological modernisation assumes that the present structure of economic growth can be harmonised with environmental sustainability by using market mechanisms to drive the transition from the present fossil-fuel-based technological base. However, many researchers indicate that, absent radical technological breakthroughs, the short time horizon of a couple of decades to keep the emissions down to the limit the average global warming compared to the pre-industrial levels to the aspired 1.5 or 2°C while preserving Earth’s ecosystems might be too short for the existing green technologies, deployed at the historical and present rates of technological replacement and the level of investment into these technologies (Loftus et al. 2015: @anderson\_trouble\_2016, Allwood 2021, Hansen, Sato, and Kharecha 2021).

Even if these policies are banking on the unprecedented pace of development and deployment of green technologies to tackle enormous challenges of decarbonising the world, there is some merit to those expectations: pollution does happen through technologies. However, there is also a limitation to them: energy generation, manufacturing processes, industrial food production, heating and cooling are highly complex and large-scale infrastructures, sustained by highly profitable and taxable fossil-fuel industries. Such interlocking large-scale infrastructures, which have been likened to a geological sphere — a technosphere, might make the sudden, disruptive change to their operation more difficult than were the changes in communication, coordination, and administration brought about by digital technologies. To add to the challenge, the temporal horizon for this immense technology and energy transition is limited. Contemporary capitalist metabolic patterns premised on high intensity extraction of matter and conversion of energy from nature have been developed and built out over centuries. Replacing them in few short decades might not be achievable. Therefore, the strategy that places primacy on technologies in rapid transition might not yield the results on time, implying that societies globally might need to ponder other significant transformations, such as to their economic systems and the systems of provision for social needs, to meet their climate goals more easily and thus to bring the world more expediently within the bioregenerative capacities of the planet Earth. To reverse the expectation, is it not the technology-first strategy that might need to be disrupted?

Indeed, As the intergovernmental climate and biodiversity scientific bodies IPCC and IPBES attest, planetary ecological crisis calls for “transformative changes across economic, social, political and technological factors” (IPBES 2019). And while scientists call for transformative changes across a number of societal (sub)systems, policymakers are focusing primarily on the changes to technology and energy systems while avoiding direct interventions into the wasteful and unsustainable socioeconomic and sociometabolic patterns of production and provision for social needs that are sustained by these technological and energy systems because social or political changes are more difficult to negotiate and enact than technological changes, both nationally and, in particular, internationally.

The primary objective of this thesis is to investigate the proposals of socioeconomic and sociometabolic transformation that can fill the gap between what science calls for and what policy delivers, proposals that might counteract the potential failings of the current “technology-first” approach to address the planetary ecological crisis timely. The shortening time window for climate action makes it urgent and necessary that the proponents of these alternative pathways to sustainability shift the dominant framing of climate protection from the principles of ecological modernisation, premised on harmonising economic growth with environmental sustainability, to a framing that will safeguard the wellbeing of all within limits of a stabilised planetary ecology. The thesis is responding to the urgency and the necessity of that frameshift (Ansari, Wijen, and Gray 2013).

To pursue that objective in this thesis, I will focus specifically on two framings, their two proponents and their exemplary agency, to reflect the fact that social metabolisms encompass both the systems of production and the systems of provision for social needs and that they vary immensely between the affluent countries capitalist core and the capitalist (semi)periphery. In the context of the European post-socialist (semi)periphery, I will investigate the activities of the Institute for Political Ecology (henceforth IPE), a research and education organisation developing proposals of degrowth policies. In most general terms, degrowth offers a framing in which the limiting of economic growth in affluent and polluting economies, accompanied by a redistribution of social wealth and an effort to design an economy aimed at the wellbeing of all, would lower the demand for material extraction and energy generation, and thus ease the technological challenge of achieving rapid decarbonisation and ecosystems reparation. On the other side, in the context of the European capitalist centre, I will investigate the activities of the UK’s largest industrial labour organisation, Unite the Union (henceforth Unite), whose environmental activities have focused on developing proposals of green industrial revolution and green new deal. Green new deal offers a framing in which the greening of the economy is fundamentally tied to making increasingly unequal economic systems more equitable and welfare provisions more comprehensive. To facilitate that double social and technological transformation, such proposals are frequently premised on the nationalisation of key polluting sectors such as energy and transport and the socialisation of healthcare, education and housing.

The selection of these two actors is motivated by a desire to complicate the binaries through which their framings are typically understood: working-class vs lifestyle environmentalism, capitalist core vs periphery, production vs social reproduction. By providing a thick account of the strategic-operational contexts of these organisations, their respective environmentalists and their work, the thesis is aspiring towards a unified understanding of the two frequently contrasted environmental positions.

The thesis grounds this account in historical, strategic and political-epistemic analyses of the challenges these alternative framings and their proponents face, drawing on a variety of disciplines and approaches — including ecological Marxism, environmental history, critical theory of technology, organisational theory and Earth system science — to discuss technological change, sociometabolic transitions, the strategic agency in structure, production of knowledge and expertise to outline the technological and institutional challenges these actors face. Starting from that analytical framework, I engage with the selected case study organisations directly through my fieldwork. The primary focus of case studies is on the organisation-field dynamic: how the IPE and the Unite as organisations can affect the field of climate and environmental action, rather than the individual-organisation dynamic that shapes the work of these organisations from within.

The methodology I have selected for the fieldwork is aimed at the interpretivist institutional analysis of how these organisations work to change the framing of climate and environmental action. However, it also has a moment of mutual reflexivity in expertise-building, as I make an effort to contribute with my research and presence to their research and activities. The approaches I have selected and used in conducting these case studies, although somewhat impaired in their implementation by the intervening circumstances of the COVID-19 pandemic, were participant observation, semi-structured interviews, analysis of primary and secondary literature, and co-research, allowing for a pluriperspectival capture of the institutional logics and strategic agency of these organisations. Furthermore, I engage the organisations in the spirit of militant research, directly supporting, amplifying and extending their caus of urgent and necessary counterproposals and counteraction to the technology-first approach.

The thesis contributes to the understanding of the social agency of environmental groups and trade unions from the vantage point of how these actors respond to the dominant technology-first approach in the global environmental policymaking, an approach that is designed so to avoid interventions into the socioeconomic and sociometabolic patterns of production and provision for social needs that are sustained by these technological and energy systems. Furthermore, it contributes to the understanding of how such proposals are grounded in distributional conflicts, responding to the socially unequal and environmentally unjust present, and are oriented toward a more sustainable and just future. Relatedly and finally, the thesis contributes to the understanding of how the future dimension of transition proposals, for reasons of accumulated pollution and destabilisation of Earth’s biophysical process, is not an open horizon where all transition scenarios are equally possible and adequate regardless of when and with what elements they unfold. Starting from Herman Daly’s notion of a “full world” (Daly 2005), I analyse the two environmentalists in this thesis from the perspectives of real-utopian prefiguration (Boggs 1977, Wright 2011) and speculative construction (Stengers 2008, Puig de la Bellacasa 2009).

# 1.2 Development of research

This research has developed from my experience of joint activist work with environmental groups in Croatia and the former Yugoslavia over the last fifteen years. Since the early 2000s, while being part of the theory and publishing programme team at the Multimedia Institute/MAMA, a cultural space and an organisation run by a collective in Zagreb, my pursuits have expanded from philosophy and social theory to hacktivism, access to knowledge and the commons. Building on that shared interest in the commons and public access to goods, initially rooted in the digital domain, our collective started to interrogate the processes of redevelopment of urban spaces, industrial sites and agricultural land that in the latter part of the 2000s transformed these societal goods under Yugoslav socialism into new territories of dispossession and accumulation. The collective, myself included, helped initiate the Right to the City movement in Zagreb and helped organise a series of mass mobilisations that contested the privatisation of public space, agricultural land for golf course development, national system of highways and public services. Throughout these mobilisations, which lasted between 2006-2015, the Right to the City - Zagreb collaborated closely with Croatia’s largest environmentalist organisation and Friend of the Earth affiliate Green Action and public sector trade unions (Medak 2017).

Toward the end of that period my intellectual interests shifted toward researching economic and social drivers of technological change. This led to being asked on repeated occasions by environmentalist groups to present on technological change as it related to climate change and planetary ecological crisis. In 2016 at the Green Academy and at the international Degrowth conference, both co-organised by the Institute for Political Ecology, I gave talks on “Technologies for an Ecological Transition” (Medak 2018), presenting my research on the affordances and pitfalls that alternative technological development offered for a transition to a post-growth social metabolism, with a particular interest in what actors hailing from the semi-periphery that is Croatia could do and should strive for. This was my first foray into research interests that have led to this thesis. Since 2016 I have increasingly become involved in environmental politics. This was the primary factor motivating me to develop a framework to understand better the strategic capacity that actors such as environmentalist groups and trade unions can have in shaping the direction of future technological changes while safeguarding that these changes also lead to more sustainable and just socioecological arrangements as compared to the extractivist, growthist and uneven capitalist development.

Finally, it is worth mentioning that my interest in technologies and environmentalism would have ramifications beyond research in this thesis. Through my involvement with the municipalist green-left platform Zagreb je NAŠ! and the national green-left platform Možemo!, I have become member of the working bodies of a political party that has recently, and somewhat unexpectedly, gained significant leverage on local and national environmental politics, winning five parliamentary seats in the 2020 national elections and the mayoral position and majority in the city assembly of Zagreb in the 2021 municipal elections. Two aspects of this research bear out on my political engagement. Firstly, in a context of environmental policy dominated by technology-first approach, which frequently and purposefully remains agnostic toward the social aspects of technological transition, the research in this thesis highlights social processes that drive technological change and diverging social outcomes that are resulting from different technological choices. Relatedly, rapid decarbonisation, ecosystem restoration and other urgent measures to stabilise the Earth’s subsystems necessitate changes to how societies structure the systems of provision for the needs of their citizens. One of the take-aways from my research is that these changes frequently need to be first experienced before they can gain popular acceptance and democratic legitimation. Secondly, in that collective familiarisation with new, more sustainable and just modes of living, social actors such as environmental groups or labour organisations that are neither scientists, nor corporations, nor governments — and thus operate in what I will call the “middle ground”, where they shape quotidian practices and common senses — play a catalysing role. The implication is that an essential part of environmental policy should be to support and strengthen the strategic agency of these actors, which is something I will be arguing in this thesis.

# 1.3 Research objectives and questions

Starting form the development of my research interests and my evolving embeddedness in the environmental debates outlined in the previous section, as well as strarting from a survey of the state of knowledge I will outline below in the contribution to knowledge, I have set the following overall goal for the research in this thesis:

**Overall goal**: To develop understandings of the strategic capacity of environmental actors, as situated in structural relations of power, to shift the frame of environmental action away from the technology-first approach and to orient social development towards a more sustainable and just social metabolism.

This goal responds to the research question in the subtitle of this thesis:

Can the planetary technosphere be politically steered toward a post-capitalist metabolism?

The research pursues this goal through three research objectives and three related questions:

**Objective 1**: To provide a *historical analysis* of how the presently dominant fossil-fuel-based industrial capitalist social metabolism emerged, evolved and consolidated. Responding to the research question:

What processes have driven the transitions to the presently dominant sociometabolic regime, and, in turn, what impediments does that regime impose on achieving sustainable and just social metabolisms in the future?

**Objective 2.**: To elaborate elements of a *critical theory of technology* and *political epistemic analysis* that delimit the strategic capacity of various actors to shape processes of technological and sociometabolic change. Responding to the research question:

Can social actors that are neither governments, corporations or scientists be catalysts of technological and sociometabolic change, can they envision the transition, produce the necessary expertise, and give direction to such transitions in significant ways?

**Objective 3.**: To engage with two such actors, an environmental group in Croatia and an industrial trade union in the UK, analysing and contributing to their agency in technological and sociometabolic change. Responding to the research question:

How do such actors concretely envision and shift the frame of action to such technological and sociometabolic change — within the capitalist relations of production and within the capitalist social metabolism?

The historical, theoretical and epistemic analyses are provided in chapters 2, 3 and 4, whereas the engagement with the Institute of Political Ecology (henceforth IPE) and Unite the Union (henceforth Unite) are discussed in chapters 6 and 7.

# 1.4 Gap in research and contribution to knowledge

My inquiry is triangulating between existing research on social agency, technological change and planetary ecological destabilisation. It draws on a substantial body of research on the role of technological and energy systems in causing and mitigating ecological degradation. I will be engaging with key texts within this literature throughout this thesis.

More specifically, my inquiry is situated within a variety of subdisciplines and approaches in technology studies discussing a determining role of technologies in social change and a determining role of social relations on technological change — including the social construction and social shaping of technology (MacKenzie and Wajcman 1999, MacKenzie 1998, Schwartz Cowan 1985, Hughes 1993), science and technology studies (Sismondo 2009, Latour 2012, Callon 1990, Law 2002), neo-Schumpeterian techno-economic paradigms (Freeman and Louçã 2001, Perez 2011, Mazzucato 2013) or Marxian critique of technology (Slater 1980, Smith and Marx 1994, Davis, Hirschl, and Stack 1998, Feenberg 2002, Noble 2011, Dyer-Witheford 2015).

Furthermore, my inquiry is situated within the research focus on sociometabolic transitions that has now been three decades in the making, most notably in environmental history (Cronon 1992, Pomeranz 2000, Merchant 1987, Barca 2011), environmental humanities (Chakrabarty 2009, Ghosh 2016), ecofeminism (Merchant 1987, Plumwood 2005, Haraway 2016, Tsing 2015, Barca 2020), ecological Marxism (Burkett and Foster 2006, Foster, Clark, and York 2011, Huber 2013) and social ecology (Sieferle 2001, Krausmann et al. 2008, Fischer-Kowalski 2011).

There is now a growing body of research, much of it participatory or ethnographic, done on the role of activism and trade unionism in the global environmental arena (Reitan and Gibson 2012, Klein 2014, Malm 2021, Hampton 2015, Barca and Leonardi 2018, Riofrancos 2020). However, *there is limited research on the shaping capacity of environmental activism and trade unionism on technological change in sociometabolic transitions*. My thesis sits in this gap.

*The thesis contributes specifically to the understanding of the social agency of environmental groups and trade unions from the vantage point of how these actors respond to the ecological modernisation approach in global environmental policymaking. This approach has primarily focused on changes to technology and energy systems with the support of the markets* while avoiding interventions into the sociometabolic patterns of production and provision for social needs that are sustained by these technological and energy systems. Through the theoretical conceptualisation that sets the analytical framework for my fieldwork, the thesis explores to what degree such technology-first strategies can deliver on the ambitious goals that the global policymaking processes place on them (chapter 3). Furthermore, it explores to what degree technologies limit and enable the strategic capacity of the actors that are not perceived as agents of technological change. These actors are typically considered reactive to technological change. In my thesis, however, I want to tease out, in both theoretical and evidentiary ways, the aspects of their work in which they can be understood and analysed as active agents shaping the framing and future direction of technological and sociometabolic change (chapters 4 and 5). Throughout the two case studies I have conducted conducted with the Institute of Political Ecology (chapter 5) and the Unite (chapter 6), my working hypothesis has been that environmental groups and trade unions respond to the technology-first context in two ways. Firstly, they *produce their own expertise*, translating the realities of ecological crisis into proposals and actions for future social and sociometabolic transformations of the capitalist industrial world. Second, they *envision, advocate and advance technologies* that would support such sociometabolic transformations.

Furthermore, *the thesis contributes to the understanding of how such proposals developed by environmental groups and trade unions are grounded in distributional conflicts, responding to the socially unequal and environmentally unjust present, and are oriented toward a more sustainable and just future.* A potential inadequacy of global governance’s technology-first approach to preventing runaway climate change might necessitate — sooner rather than later — “transformative changes across economic, social, political and technological factors” that the scientists are calling for (IPBES 2019). A major obstacle for instituting such changes in the global policymaking process, however, lies in the fact that societal arrangements across the world are heterogeneous and entrenched into asymmetries of power, so pursuing technological change in a capitalist world-system, where technologies are diffused from the capital-intensive, polluting economies of the core of the world-system, is easier than changing existing societal arrangements. The problem, nonetheless, persists if technological change cannot achieve the goals set out for the technology-first strategy in time and adequately, and so deeper sociometabolic changes might be necessary to prevent or compensate for the failure of the technology-first strategy. The visions and proposals for a sustainable and just future that actors I work with in this thesis bring to the table might thus have a formative role in shaping that about-turn.

Relatedly and finally, *the thesis contributes to the understanding of how the future dimension of transition proposals is not an open horizon where all transition scenarios are equally possible and adequate regardless of when and with what elements they unfold.* Starting from Herman Daly’s notion of a “full world” (Daly 2005), i.e. an Earth system that is already so destabilised from its Holocenic variability by the scale of pollution that only some future scenarios might keep it habitable for societies and ecosystems to the degree it is now, I will discuss the present challenges and future horizons that degrowth and working-class environmentalisms have ahead of them. These I will consider from the perspectives of real utopian prefiguration (Boggs 1977, Wright 2011) and speculative construction (Stengers 2008, Puig de la Bellacasa 2009).

# 1.5 Thesis outline

The next chapter, **Chapter 2**, is the thesis’s methodology chapter. I build on the explanation of the research context provided in this introduction to further elaborate how the selection of the two organisations for my case studies — IPE in Croatia and Unite in the UK — dovetails with research question 3 (i.e. how do such actors envision and shift the frame of action away from the technology-first approach — within the capitalist relations of production and within the capitalist social metabolism?). Initially, my plan was that both of my case studies would be conducted as collaborative research. I have sought to work together, for a period of time, with both organisations to learn from and contribute to their expertise and their agency in the technology-first context of environmental action. Given my previous collaboration with the IPE and plans to collaborate with Unite, an engagement characterised by alignment and allyship with their interests and actions, made such a collaborative and militant research approach appropriate. While I have managed to put into action such an approach with the IPE, contributing in substantive ways to their research, education and publishing activities, my collaboration with the Unite was cut short by the COVID-19 pandemic and had to be transformed into an observational engagement that rested on structured interviews and document analysis. The chapter further details the methods I have used and provides an account of the positionality and ethics of the initial and adapted approaches I have taken.

The methodology chapter segues into three chapters where I am developing my historical, strategic and political-epistemic conceptualisation that sets the analytical framework for my fieldwork. These arguments highlight three aspects in the sociometabolic transition — technology, social agency and governance. Roughly they follow this schema:

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Chapter 3** (historical analysis) | **Chapter 4** (agential analysis) | **Chapter 5** (political epistemic analysis) |
| **Agency** | drivers of historical change: technology or social agency? | critical theory of technology | actors in the “middle ground” |
| **Technology** | modernisation and consolidation of fossil capitalism | technological determinism | capitalist cosmology and environmental rationality |
| **Governance** | international governmentalisation of energy and economy | strategic-relational approach | liberal governance and global politics of climate science |

*Table 1. Topical organisation of chapters 3, 4 and 5.*

**Chapter 3** harks back to a series of social, technological and energy transformations from the 16th to the late 20th century that have led to the presently dominant fossil-fuel-based industrial capitalist social metabolism. It retraces significant and entwined historical moments of transition from feudalism to capitalism, from renewable sources of energy to first coal and then oil, from largely steady-state agricultural economies to the globalised industrial economy of growth premised on intensifying throughput of energy and matter, from the conservation of energy to inefficient large-scale energy systems, from the early colonial capitalism to neo-imperial unequal ecological exchange. The central question that I explore as part of this genealogy is whether historical transitions were driven by the forces of production or the social relations of production, i.e. by technological advances or class antagonism. I discuss particularly the transition from water to coal during the early industrial revolution to indicate that the direction of causation alternates between the two, suggesting the inadequacy of the technology-first approach of the global climate change governance in the current energy transition. If the globally governed decarbonisation effort is to meet the net-zero goal rapidly enough to stay within the aspired 1.5°C or 2°C average global temperature rise compared to the pre-industrial levels, it might require not only technological but also social and systemic changes.

**Chapter 4** parallels the development of the historical argument in chapter 3 with a theoretical argument on technological change and strategic agency. By drawing on the critical theory of technology and science and technology studies, in this chapter I will put forward an outline of a theory of agency in social structure that allows me to analyse how the direction of technological change can be impacted and shifted by actors other than corporations, technologists and governments. In conclusion I will argue that actors such as environmental groups and trade unions can play an active role in the social shaping of technology, a process that extends from the design table, regulatory conditions, market competition, public contestation, all the way to continued use. However, as I will show in this chapter, the path dependence of fossil-fuel-based technological development and the asymmetries of capitalist economic power result in significantly different capacities of various social actors to effectively impact technological change between corporations, governments and citizens. To theoretically ground that observation of power asymmetries and selectivity of the existing social structure toward interventions of different agents, I discuss the theories of technological determinism and Bob Jessop’s strategic-relational approach to analysing agency in social structure. To close off the chapter, I argue that despite this asymmetry, the dependence of technological systems on regulatory arrangements and energy systems make them susceptible to political contestation and disruption, thus opening an avenue for rapid and non-gradual technological disruption outside of the global governance process. I will therefore conclude that protests and strikes can create an opening for proposals of a more substantive social change.

**Chapter 5** is an excursus in which I discuss the positionality of actors that I research within the broader context of knowledge production around climate change and ecological crisis. It thus complements and extends my methodological considerations. These organisations, although neither scientific institutions nor policymaking bodies (thus operating in what I define as the social “middle ground”), do engage in research activities and produce expertise of their own to translate environmental science into common sense and lived reality. To elaborate how the epistemic politics of such organisations that have “subjective” and “material” stakes in social reality can be reconciled with the objectivist principles of science, I analyse their work through the lens of feminist standpoint epistemology and the “postnormal science” necessitated by the urgency of crisis (Funtowicz and Ravetz 2006). From the discussion of the epistemic positionality of the research activities of these organisations, I will move onto considering broader politics of knowledge, asserting that the science-based climate change governance is rooted in the post-WWII global liberal order, but at the same time subverted by the economic neoliberalisation and the inequalities this same order has birthed. Finally, I revisit the debate around the epistemic universality vs plurivesality to claim that all societies and their cosmologies can be made commensurate based on their ecological rationality.

The three theoretical conceptualisation chapters segue into two case study chapters that draw on my fieldwork with the IPE and Unite respectively. Both comprise of three macro-segments: discussion of a particular environmentalism, analysis of the organisation and my engagement with the organisation, and a speculative exploration of the challenges and opportunities their form of environmentalism offers for the transformation of the presently dominant fossil-fuel-based industrial capitalist social metabolism.

|  |  |  |
| --- | --- | --- |
|  | **Chapter 6** | **Chapter 7** |
| **Environmentalism** | degrowth | working-class |
| **Case study** | Institute for Political Ecology | Unite the Union |
| **Position in the world-system** | semi-periphery | core |
| **Collaborative research** | degrowth doughnut |  |
| **Futurity** | real utopias | just transition |

*Table 2. Structure of two case studies.*

The first of the two, **chapter 6**, developed during my fieldwork with the IPE that lasted for the better part of 2019, starts by detailing the emergence of degrowth as social-metabolism-oriented environmentalism out of environmental economics. Degrowth parallelly consolidated into a global movement and a research project, developing proposals, theoretical and practical, on how to transform the destructive sociometabolic patterns of affluent societies by lowering the throughput of energy and matter, redistributing social wealth and allowing a pluriverse of material and epistemic routes to social development outside capitalism. From this general outline of degrowth environmentalism, the chapter segues into the work and positions of the IPE, which I analyse using the research I participated in, structured interviews with three members of the organisational team and an analysis of the organisation’s publications. The principal aspect of my engagement with the organisation is the development of a “degrowth doughnut” that I contextualise within the history of modelling society-nature interactions from the simple model used in the *Limits to Growth* study (Meadows et al. 1972) to the models used by the IPCC. Unlike Kate Raworth’s initial doughnut proposal (Raworth 2017), the “degrowth doughnut” is aimed at overcoming the zero-sum game between actions that restore nature and actions that heighten the social foundation, claiming that we should go beyond the opposition of nature to society. The chapter concludes on a reflection how degrowth environmentalism is proposing a real-utopian horizon of sociometabolic transformation built on prefigurative practices, one that is taking “full world” of destabilised planetary boundaries realistically as truly limiting and that is proposing a framework of policies for a socially just and environmentally sustainable space for all of humanity.

The second case study, the basis for **chapter 7**, was initiated in late 2019 and was unexpectedly interrupted with the onset of the COVID-19 pandemic. Thus, much of the planned collaboration could not develop and beyond the initial structured interview with the Director of Education at Unite, the chapter developed out of the primary document analysis and literatures on working-class environmentalism. In chapter 7, I first outline elements of working-class environmentalism, conceptualising the separation of the internal from external nature within capitalism, as well as the various forms of environmental vulnerability of the working class. From there, I analyse the strategic agency of the working class within the economic and environmental domain, arguing that organised labour and trade unionism developed forms of power from below that have significantly disrupted and changed the direction of social development to create more democratic and environmentally safer societies. My analysis of Unite’s climate strategy is situated in that history, outlining its specific ambivalent positioning to environmental action that includes both radical components of green industrialisation and conservative components of supporting polluting industries such as mining. The threat of the working class losing once again in the next transition (after it did in the UK’s transition from coal) calls for the strategies of just transition that will provide security and jobs for the communities of workers that will be left unemployed in the closing of fossil economy. I conclude the chapter with a discussion of the waning political fortunes of the Green New Deal proposals that have argued that addressing social inequalities is a necessary prerequisite of climate action. I argue that given the fragmentation of labour movement resulting from technological change, it is on other environmentalisms to support the unionisation and help trade unionism again gain ground to advocate for more radical environmental proposals.

In the concluding chapter, **chapter 8**, I return to the initial research questions to argue how the take-aways from the two case study chapters, as well as the historical, strategic and political-epistemic inquiries of the present social metabolism and social agency capable of transforming it in earlier chapters, combine in novel ways to contribute to knowledge of the ecological agency. The chapter also lays out further avenues of research that could not be explored in this thesis but would benefit its research objective.

# Bibliography

Allwood, J. (2021) ‘Technology Will Not Solve the Problem of Climate Change’. *Financial Times* [online] 16 November. available from <<https://www.ft.com/content/207a8762-e00c-4926-addd-38a487a0995f>> [18 November 2021]

Anderson, K. and Peters, G. (2016) ‘The Trouble with Negative Emissions’. *Science* [online] 354 (6309), 182–183. available from <<http://science.sciencemag.org/content/354/6309/182>> [24 December 2016]

Ansari, S., Wijen, F., and Gray, B. (2013) ‘Constructing a Climate Change Logic: An Institutional Perspective on the “Tragedy of the Commons”’. *Organization Science* 24 (4), 1014–1040

Bäckstrand, K. and Lövbrand, E. (2007) ‘Climate Governance Beyond 2012: Competing Discourses of Green Governmentality, Ecological Modernization and Civic Environmentalism’. in *The Social Construction of Climate Change: Power, Knowledge, Norms, Discourses*. Ashgate Aldershot, 123–147

Barca, S. (2020) *Forces of Reproduction: Notes for a Counter-Hegemonic Anthropocene* [online] Cambridge University Press. available from <<http://books.google.com?id=7WrazQEACAAJ>>

Barca, S. (2011) ‘Energy, Property, and the Industrial Revolution Narrative’. *Ecological Economics* 70 (7), 1309–1315

Barca, S. and Leonardi, E. (2018) ‘Working-Class Ecology and Union Politics: A Conceptual Topology’. *Globalizations* [online] 15 (4), 487–503. available from <<https://doi.org/10.1080/14747731.2018.1454672>> [10 October 2019]

Boggs, C. (1977) ‘Marxism, Prefigurative Communism, and the Problem of Workers’ Control’. *Radical America* 11 (6), 99–122

Burkett, P. and Foster, J.B. (2006) ‘Metabolism, Energy, and Entropy in Marx’s Critique of Political Economy: Beyond the Podolinsky Myth’. *Theory and Society* 35 (1), 109–156

Callon, M. (1990) ‘Techno-Economic Networks and Irreversibility’. *The Sociological Review* 38 (1\_suppl), 132–161

Chakrabarty, D. (2009) ‘The Climate of History: Four Theses’. *Critical Inquiry* 35 (2), 197–222

Cronon, W. (1992) *Nature’s Metropolis: Chicago and the Great West*. New Ed edition. New York: W. W. Norton & Company

Daly, H.E. (2005) ‘Economics in a Full World’. *Scientific American* 293 (3), 100–107

Davis, J., Hirschl, T., and Stack, M. (eds.) (1998) *Cutting Edge: Technology, Information Capitalism and Social Revolution*. First Edition edition. Verso

Dyer-Witheford, N. (2015) *Cyber-Proletariat: Global Labour in the Digital Vortex*. London, U.K.: Pluto Press

Feenberg, A. (2002) *Transforming Technology: A Critical Theory Revisited* [online] Oxford University Press. available from <<http://books.google.com?id=soJSAwAAQBAJ>>

Fischer-Kowalski, M. (2011) ‘Analyzing Sustainability Transitions as a Shift Between Socio-Metabolic Regimes’. *Environmental Innovation and Societal Transitions* [online] 1 (1), 152–159. available from <<http://www.sciencedirect.com/science/article/pii/S2210422411000153>> [25 July 2019]

Foster, J.B., Clark, B., and York, R. (2011) *The Ecological Rift: Capitalism’s War on the Earth*. NYU Press

Freeman, C. and Louçã, F. (2001) *As Time Goes by: From the Industrial Revolutions to the Information Revolution* [online] OUP Oxford. available from <<http://books.google.com?id=sZgs6YBKbhUC>>

Funtowicz, S.O. and Ravetz, G. (2006) *Post-Normal Science - Environmental Policy Under Conditions of Complexity* [online] available from <<http://www.nusap.net/sections.php?op=viewarticle&artid=13>> [3 March 2019]

Ghosh, A. (2016) *The Great Derangement: Climate Change and the Unthinkable* [online] University of Chicago Press. available from <<http://books.google.com?id=ImcpDQAAQBAJ>>

Hampton, P. (2015) *Workers and Trade Unions for Climate Solidarity: Tackling Climate Change in a Neoliberal World*. Routledge

Hansen, J., Sato, M., and Kharecha, P. (2021) *November Temperature Update and the Big Climate Short*. available from <<http://www.columbia.edu/~jeh1/mailings/2021/NovemberTUpdate+BigClimateShort.23December2021.pdf>>

Haraway, D. (2016) *Staying with the Trouble: Making Kin in the Chthulucene* [online] Durham, NC: Duke University Press. available from <<http://books.google.com?id=ZvDgDAAAQBAJ>>

Huber, M.T. (2013) *Lifeblood: Oil, Freedom, and the Forces of Capital* [online] University of Minnesota Press. available from <<http://books.google.com?id=OpWwswEACAAJ>>

Hughes, T.P. (1993) *Networks of Power: Electrification in Western Society, 1880-1930* [online] Baltimore, MA: The John Hopkins University Press. available from <<http://books.google.com?id=g07Q9M4agp4C>>

IPBES (2019) *Global Assessment on Biodiversity and Ecosystem Services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*. ed. by Brondizio, E.S., Settele, J., Díaz, S., and Ngo, N.T. IPBES. available from <<https://www.ipbes.net/global-assessment-biodiversity-ecosystem-services>> [10 June 2019]

Klein, N. (2014) *This Changes Everything: Capitalism Vs. The Climate* [online] New York: Simon and Schuster. available from <<http://books.google.com?id=kxJ5BAAAQBAJ>>

Krausmann, F., Fischer-Kowalski, M., Schandl, H., and Eisenmenger, N. (2008) ‘The Global Sociometabolic Transition: Past and Present Metabolic Profiles and Their Future Trajectories’. *Journal of Industrial Ecology* 12 (5-6), 637–656

Latour, B. (2012) *We Have Never Been Modern* [online] Cambridge, MA: Harvard University Press. available from <<http://books.google.com?id=xbnK8NzMsm4C>>

Law, J. (2002) *Aircraft Stories: Decentering the Object in Technoscience* [online] Duke University Press. available from <<http://books.google.com?id=8Chz2rM0HVIC>>

Loftus, P.J., Cohen, A.M., Long, J.C.S., and Jenkins, J.D. (2015) ‘A Critical Review of Global Decarbonization Scenarios: What Do They Tell Us About Feasibility?’ *Wiley Interdisciplinary Reviews: Climate Change* [online] 6 (1), 93–112. available from <<http://onlinelibrary.wiley.com/doi/10.1002/wcc.324/abstract>> [24 December 2016]

MacKenzie, D. (1998) *Knowing Machines Essays on Technical Change (Inside Technology)*. New Ed edition. The MIT Press

MacKenzie, D. and Wajcman, J. (1999) *The Social Shaping of Technology*. Open university press

Malm, A. (2021) *How to Blow up a Pipeline* [online] Verso Books. available from <<http://books.google.com?id=AF4NEAAAQBAJ>>

Mazzucato, M. (2013) *The Entrepreneurial State: Debunking Public Vs. Private Sector Myths*. Anthem Press

Meadows, D.H., Meadows, D.L., Randers, J., and Behrens, W.W. (1972) *The Limits to Growth: A Report for the Club of Rome’s Project on the Predicament of Mankind*. New York, NY: Universe Books

Medak, T. (2018) ‘Technologies for an Ecological Transition: A Faustian Bargain?’ in *Materialism and the Critique of Energy* [online] ed. by Bellamy, B.R. and Diamanti, J. Chicago & Alberta: MCM’, 525–544. available from <<http://www.mcmprime.com/files/Materialism_Energy.pdf>> [8 October 2018]

Medak, T. (2017) ‘From Independent Cultural Work to Political Subjectivity’. in *The Art of Civil Action: Political Space and Cultural Dissent*. ed. by Dietachmair, P. and Gielen, P. Antennae - Arts in Society. Amsterdam: Valiz, 207–227

Merchant, C. (1987) ‘The Theoretical Structure of Ecological Revolutions’. *Environmental Review* [online] 11 (4), 265–274. available from <<http://www.jstor.org/stable/3984135>>

Noble, D.F. (2011) *Forces of Production* [online] New Brunswick, NJ: Transaction Publishers. available from <<http://books.google.com?id=3Q4DStBzbi0C>>

Perez, C. (2011) *Finance and Technical Change : A Long-Term View : Research Paper*. [online] available from <<http://reference.sabinet.co.za/sa_epublication_article/aa_ajstid_v3_n1_a2>> [6 May 2015]

Plumwood, V. (2005) *Environmental Culture: The Ecological Crisis of Reason* [online] Routledge. available from <<http://books.google.com?id=3V4SCHer39MC>>

Pomeranz, K. (2000) *The Great Divergence: China, Europe, and the Making of the Modern World Economy* [online] Princeton University Press. available from <<http://books.google.com?id=W2GYDwAAQBAJ>>

Puig de la Bellacasa, M. (2009) ‘Touching Technologies, Touching Visions. The Reclaiming of Sensorial Experience and the Politics of Speculative Thinking’. *Subjectivity* [online] 28 (1), 297–315. available from <<https://doi.org/10.1057/sub.2009.17>> [14 December 2021]

Raworth, K. (2017) *Doughnut Economics: Seven Ways to Think Like a 21st-Century Economist*. Reprint edition. Chelsea Green Publishing

Reitan, R. and Gibson, S. (2012) ‘Climate Change or Social Change? Environmental and Leftist Praxis and Participatory Action Research’. *Globalizations* [online] 9 (3), 395–410. available from <<https://doi.org/10.1080/14747731.2012.680735>> [25 February 2018]

Riofrancos, T. (2020) *Resource Radicals: From Petro-Nationalism to Post-Extractivism in Ecuador*. Duke University Press

Schwartz Cowan, R. (1985) *More Work for Mother: The Ironies of Household Technology from the Open Hearth to the Microwave*. New York, NY: Basic Books

Sieferle, R.P. (2001) *The Subterranean Forest: Energy Systems and the Industrial Revolution* [online] White Horse Press. available from <<http://books.google.com?id=ikS0AAAAIAAJ>>

Sismondo, S. (2009) *An Introduction to Science and Technology Studies*. 2nd edition. Chichester, West Sussex, U.K.: Wiley-Blackwell

Slater, P. (1980) *Outlines of a Critique of Technology*. Ink Links

Smith, M.R. and Marx, L. (1994) *Does Technology Drive History?: The Dilemma of Technological Determinism*. MIT Press

Stengers, I. (2008) ‘A Constructivist Reading of Process and Reality’. *Theory, Culture & Society* 25 (4), 91–110

Tsing, A.L. (2015) *The Mushroom at the End of the World: On the Possibility of Life in Capitalist Ruins* [online] Princeton, NJ: Princeton University Press. available from <<http://books.google.com?id=Ix68rQEACAAJ>>

Wright, E.O. (2011) ‘Real Utopias’. *Contexts* [online] 10 (2), 36–42. available from <<https://doi.org/10.1177/1536504211408884>> [14 December 2021]

1. The exponential expansion of microcomputing and digital networks over the last three decades has come to shape the contemporary popular expectations of how quickly technologies can change. Digital technologies are perceived as maverick forces of creative destruction of old oligopolies and disruption of bureaucratised institutions. These expectations are nowhere more in evidence than in the unprecedented trillion-dollar valuations that financial markets bestow on Big Tech. Some of the transformations facilitated and driven by digital technologies have indeed been unprecedented. Computerised control, coordination and optimisation of complex, geographically distributed processes has accelerated the integration of the post-1989 global free markets, the relocation of manufacturing to South East Asia and the creation of global just-in-time supply chains. These transformations only pale in comparison to the changes digital technologies have brought to private and mass communication. These disruptions have not come without significant social and political destabilisation, drawing increasing public and regulatory scrutiny. [↑](#footnote-ref-2)