Preface

At the time of writing (August 2021), the climate change problem featured high on societal and political agendas because of its increasingly visible effects (such as droughts, heat waves, and wildfires), civic activism and calls for action, the recent publication of the sixth assessment report by the Intergovernmental Panel on Climate Change (IPCC, 2021), and the 2021 United Nations Climate Change Conference in Glasgow.

In response to the growing sense of urgency, many countries have expressed commitments to net-zero targets by mid-century and a desire to bring about low-carbon system transitions. None of these countries, however, has yet presented a realistic and feasible implementation policy plan for reaching these targets, neither in terms of sector-specific transition pathways nor in terms of specific policies.

This problem is, at least partly, due to the dominance of integrated assessment models in climate policy debates. While these abstract formal models, which draw strongly on economic and engineering knowledge, have many strengths, they also have notable weaknesses, including oversimplified representations of social realities and system transition processes, limited attention to actors and behaviours (e.g., beliefs, meanings, strategies, politics), and narrow understandings of institutions, policies, and real-world implementation processes (Turnheim et al., 2015).

Although integrated assessment models will remain important for exploring potential long-term futures, acknowledgement of their limitations is increasingly leading to calls for deeper understandings of real-world drivers and barriers in the low-carbon transitions that are presently unfolding at varying speed, scope, and depth in different sectors and countries. The IPCC's 1.5°C report (IPCC, 2018), for instance, started analysing the multi-dimensional feasibility of different low-carbon innovations and system transition pathways, while the UK Committee on Climate Change (2021: 33) aims to provide more implementation-relevant knowledge by seeking to 'broaden our assessment of real-world progress,

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including public attitudes, corporate commitments, finance and the green recovery, as well as consumption emissions and the factors affecting them'.

Our book aims to contribute to these developments by deepening the social scientific knowledge of real-world system transition processes, which we think are relevant for developing realistic and feasible policy plans for reaching net-zero targets. While there are many books that analyse particular dimensions of low-carbon transitions, this book presents a reconfigurational perspective that aims to be integrative and interdisciplinary by addressing multiple relevant dimensions in transitions, including techno-economic, socio-political, cultural, and business dimensions. There are trade-offs between breadth and depth, however. So, although our integrative socio-technical system approach aims to generate more comprehensive and multi-dimensional understandings of low-carbon transitions, it may not quite satisfy disciplinary scholars who would desire a more in-depth analysis of a particular dimension such as politics or economics.

Another characteristic of our reconfigurational perspective is that it conceptualises socio-technical systems (in electricity, heat, and mobility) as heterogeneous entities and focuses on the endogenous processes, innovations, and activities that can change the elements of these entities and their interlinkages. Rather than seeing system transitions as singular disruptive processes, we thus conceptualise them as more dispersed processes that can cumulatively change the elements and architectures of existing systems. We empirically investigate if and to what degree unfolding low-carbon system reconfigurations are 'Great' (or not), by evaluating the depth and scope of changes in relevant dimensions of socio-technical system configurations. We also analyse the speed of change in unfolding transitions in relation to net zero targets and the urgency of reducing greenhouse gas emissions. Although our empirical analyses focus on electricity, heat, and mobility systems in the UK, the conceptual and conclusions chapters articulate general insights, findings, and propositions that will be of interest for non-UK academics and policymakers wanting to understand the policies and dynamics that drive real-world transition processes.

The intellectual background for the book's reconfigurational approach is socio-technical transitions research, which started two decades ago in the specialised field of innovation studies. Drawing on neo-Schumpeterian evolutionary economics and sociology of innovation, scholars in this field developed the Multi-Level Perspective, which conceptualises socio-technical transitions as multi-dimensional struggles between emerging niche-innovations and established systems, against the backdrop of exogenous context ('landscape') developments. The creation of the Sustainability Transitions Research Network in 2009 contributed to the deepening, broadening, and theoretical elaboration of socio-technical transitions research, as scholars from mainstream disciplines joined the

rapidly growing community and made important conceptual and empirical contributions. This also nurtured important and ongoing dialogues with sociology, political science, management, and environmental sciences.

The cumulative result of these contributions was that socio-technical transitions research increasingly matured, leading scholars to venture beyond specialised outlets and to start publishing in general science journals such as *Nature*, *Science*, and *Proceedings of the National Academy of Sciences* (e.g., Geels et al., 2017, 2016a; Markard, 2018; Rosenbloom et al., 2020; Sovacool and Griffiths, 2020), which enhanced visibility and credibility. Policymakers and policy-oriented organisations also showed increasing interest in socio-technical transitions research, leading transition scholars to engage in translational efforts aimed at articulating policy-relevant insights and recommendations (EEA, 2019a; Geels, 2020a; OECD, 2015; Victor et al., 2019). Many policy-oriented organisations and NGOs also adopted the socio-technical transitions framework to guide their thinking and activities (EEA, 2019b, 2018, 2017, 2016; Global Alliance for the Future of Food, 2019; JRC, 2020; Leadbeater and Winhall, 2020).

This book benefits from the maturation of socio-technical transitions research, particularly from the hundreds of detailed UK case studies that have been published on single low-carbon innovations, particular actors, or particular dimensions. This wealth of empirical qualitative research enables this book to make a next step by integrating the detailed findings into more comprehensive analyses of whole systems reconfiguration that for each domain investigate between 6–8 niche-innovations and 2–4 systems or sub-systems. Although whole systems research is well-established in the engineering and modelling communities, this kind of integrated whole systems research is unprecedented in the socio-technical transitions community. Another novel contribution is the systematic comparison of unfolding low-carbon transitions between electricity, heat, and mobility systems. While comparative research between countries is becoming more common, comparisons between systems, and reflections on the influence of their morphological differences, break new ground in socio-technical transitions research.

This book also attempts to further strengthen and deepen conversations with mainstream climate research and policy debates. Because such inter- and trans-disciplinary conversations tend to benefit from some degree of simplification (Diercks, 2018; Turnheim et al., 2020), our book streamlines the socio-technical transitions approach in at least three ways, as Chapters 1 and 2 explain. First, regarding the tangible elements of socio-technical systems, we focus on techno-economic elements and flows, which we also map quantitatively using a wide variety of statistical databases. This simplification hopefully facilitates interactions with economic modellers and engineers. Second, our operationalisation and

empirical research of rules and institutions focuses on formal policies and governance, which hopefully facilitates interactions with political scientists and policymakers. Third, with regard to actors and activities, we focus on firms, users, policymakers, and wider publics, including civil society organisations, which means we pay less attention to a wide range of other actors that are also relevant in socio-technical transitions.

This book has been a long time in the making. Initial ideas about socio-technical whole systems analysis, comparisons between systems, and efforts at inter-disciplinary bridging were developed in the context of the PATHWAYS project ('Exploring transition pathways to sustainable, low carbon societies'). This three-year research project (2013–2016), which was funded by the European Commission's Seventh Framework Program, enabled fruitful interactions between integrated assessment modellers, socio-technical transition researchers, and project implementation specialists. It also produced a range of empirical analyses of socio-technical system transitions in various domains and countries, including the UK, Netherlands, Germany, Sweden, and Portugal, which demonstrated the feasibility and relevance of the initial ideas.

A one-year post-doc project in 2017–2018, sabbatical leave in 2018–2019, and Professorial Enhanced Research Leave in 2019–2020 enabled further development of the conceptual ideas and the empirical research that led to this book. We are grateful to the Alliance Manchester Business School and the Faculty of Humanities at the University of Manchester for the financial support that made this possible. We are also grateful for having received support under the French 'Programme d'Investissements d'Avenir' (ANR-19-MPGA-0010), which allowed us to publish the book in Open Access and so reach out to a wider readership.

Over the past year, we have worked hard to finish the book, which had to be done in between other projects and commitments, and in the context of the COVID-19 pandemic, which substantially affected our available work time since we both have care responsibilities for young children. We initially intended to also include the agri-food system in our analysis, because it differs in interesting ways from the electricity, heat, and mobility systems. We reluctantly decided to exclude it, however, because of time constraints.

We are very pleased that the book is finally finished and hope that researchers from multiple disciplines as well as policymakers will find something interesting and relevant in it. Last but not least, we want to thank our families for their support, understanding, and patience while we worked to complete the book.