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INTRODUCTION

The relevance of technologies in decline

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The central question of this book is *how technologies decline*. Surprisingly, this question is fairly novel. The dominant interest in historical, economic and sociological studies of technology has been to understand how novelty emerges and how innovation can open up new opportunities. This 'innovation bias' in the disciplines studying technology reflects how in recent centuries modern societies have embraced technology as a vehicle of progress. Indeed, the development and use of technologies have brought remarkable improvements in health, mobility and standards of living. In the last two centuries, technologies were figured as solutions to address societal problems. Yet, in a time of growing concerns related to the challenges of climate crisis, biodiversity loss, social inequalities or geo-political tensions, technologies increasingly figure as part of the problem, too (cf. Beck 1992; Douglas 1970). Technologies that once embodied progress, such as pesticides or coal-fired power production, now embody problems and stand in the way of better directions. It is timely, therefore, to broaden the horizon of technology dynamics and the technology-society relationship: next to considering the rise of technologies, we should also consider their fall, too. These are two sides of the same coin when it comes to how the relationship to technology is constantly re-negotiated in a social context. In this volume we present some outlines for the study of technological decline.

1.1 Limits to innovation

After WWII most industrialised countries adopted a techno-optimistic approach. The idea was that by stimulating scientific research and technological development, society would benefit from the boons of technology. This idea became known as the 'linear model' as it assumed a direct line from scientific discovery to the implementation and diffusion of technologies (Godin 2017). The techno-optimistic view of the linear model was emblematically captured in the 1933 Chicago World Fair motto: 'Science Finds, Industry Applies, Man Conforms'.

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But, of course, men and women do not readily conform. From the 1970s onwards, critical discourses about the problems of technology became more prominent. A landmark event for the public recognition that technologies can also put society at risk was the publication of the 1972 Club of Rome report on the *Limits of Growth*. The report indicated the depletion of resources and accumulation of pollution. It also announced that the general idea that economic growth would bring progress was misguided and not necessarily consensual. While such criticisms have changed the discourses and policies on technology, it is also clear that now, 50 years later, the problems flagged have only deepened. The climate crisis and the ongoing loss of biodiversity—as corroborated by a series of IPCC and IPBES[1] reports—indicate that widely used technologies, like the internal combustion engine, coal-fired power generation or the routine preventive use of pesticides, can pose serious threats for current and future generations.

The question of technology was broadened with the issues of reducing risks and increasing democratic control—questions linking to literature on critical theory of technology, where technology is seen as neither value neutral nor universal, and opposing the privileging of technical manipulation over other relations to reality (Feenberg 2017). How to stimulate technologies while avoiding unwanted side-effects? Can unintended effects be anticipated and avoided?

1.2 Critical discourses on technology

The set of questions broadened further with the economic crises of the 1980s that saw hampered industries and painful economic reshufflings in many parts of the world. Technology appeared as the stake in intensive global competitions; national industrial policies were set up to gain a favourable position in the innovation races. As with prior techno-optimism, as if part of a cyclical pattern, this was the era of strategic research and innovation, and of significant investment programmes in ICT, biotechnology and new materials. New regional specialisations emerged under technological and competitive pressures of global capitalism. Western countries faced the social consequences of deindustrialisation in heavy industry and sought to retain competitive edges by investing in R&D for advanced technological sectors. As emerging economies in the East and South became innovation powerhouses and expanding mass consumption markets, promises of growth and prosperity provided a counterpoint to problems associated with the decline of crafts and traditional industries (e.g., hand weaving in India, cf. Mamipudi 2016). Technology and innovation remained intimately and, again, techno-optimistically, tied to economic and social prosperity, but this time there was a more widespread awareness of the downsides, and particularly the social costs of regional decline in technological races.

During the last few decades, various political initiatives have been proposed to address the removal of certain technologies. Compared to efforts to stimulate technology these initiatives are modest, but there have been some successes: for instance, the ban of chlorofluorocarbons (CFCs) under the Montreal Protocol in

1987, the chemical substances responsible for ozone depletion which were used, for instance, in refrigerators. Various forms of technology assessment are now being used in policy settings and in firms to evaluate the desirability of technologies. In EU research, the notion of 'responsible research and innovation' has become commonplace, indicating an ambition to have more public control on technologies. Currently, there is a renewed emphasis on technological sovereignty (Edler et al. 2020), to gain independence from energy sources from warring states on the occasion of the war in Ukraine, or to be less dependent on supply chains that suffered from the Covid-19 pandemic.

In recent decades, environmental, health and social concerns have begun to assume more central roles in studies on technology, innovation and economic development. The UN Millennium Goals and their extension into the UN Sustainable Development Goals are important milestones signalling new long-term global orientations for economic and technological development. The rising interest in managing the concerns relating to technologies might be stemming from the economic stagnation of the global North in the last two decades (Streeck 2014; Albertson 2020) and dissatisfaction with the way institutionalised decision-makers have been handling economic and environmental issues (Oreskes & Conway 2010; Wille 2010). We can also observe a fatigue from current hyper consumerist societies and the unresolved environmental concerns (Gibson-Graham 2008; Escobar 2015; Hossain 2018; de Saille et al. 2020; Hickel & Kallis 2020) coming from both rich and poor regions of the world. Both types of concerns manifest in a new style of protest, one that not only frames a problem explicitly, but also articulates the need to change systems by taking them down. The actions of Fridays for Future, Black Lives Matter or Extinction Rebellion are cases in point. More societal and environmental problems such as climate change, biodiversity loss, unhealthy lifestyles, redistributive justice, privacy breaches or the spread of fake news are galvanising a return to critical discourses about technology. Against this background, calls for more desirable alternatives (e.g., eco-innovation, responsible innovation) are being complemented by calls for deliberately discontinuing existing systems deemed undesirable. Phasing out coal and fossil fuels has, for instance, become an important priority for climate action. Similarly, we are witnessing the emergence of policy objectives and programmes seeking to shift food production systems towards pesticide-free agriculture. Problems around nuclear decommissioning have been around for decades, but haven't yet found widely accepted solutions.

One of the difficulties is that attempts to discontinue technologies tend to remain largely translated into new agendas and horizons for innovative activity without fundamentally challenging its underlying logics (e.g., the 'green growth' oxymoron) or established systems. Significant R&D funding is being spent to invent ways to maintain and improve lifestyles without causing deterioration of the environment. Such eco-innovation optimism is, however, struggling to deliver fully on its promises: despite significant deployment of renewable energy, electric mobility or organic agriculture in some countries, these remain a far cry from the

'fundamental system transformations' called for (IPCC 2018; EEA 2019; UNEP 2022). Meanwhile, existing technologies and underlying systems remain relatively stable (e.g., empty passenger planes flying during pandemic) or even expand (e.g., SUVs, re-opening of coal mines in Europe due to the war in Ukraine, LNG extraction plus terminals to replace natural gas shortages), while new industries that are neither ecologically sustainable nor economically necessarily viable continue to emerge (e.g., space tourism) (Markard et al. 2021). Such examples can also show how much discontinuation has to contend with contradictory or competing rationales, interests, opportunities and framings (Turnheim 2023; Stegmaier 2023; Koretsky 2023).

In short, the prominent techno-optimistic discourses are under pressure, and existing socio-technical systems, ranging from energy production, to mobility, to agri-food, are increasingly under critique. As a result, many questions come to the fore: Is it possible to do away with undesirable or unsustainable technologies? If so, how? Does this necessarily involve substitution or does it involve other shifts, too? What societal, political and industrial strategies may help to reduce our dependence on harmful technologies and socio-technical systems? Should specific products or larger systems be targeted? How can investment patterns related to harmful and polluting production be discontinued? These questions require another approach to technology: exits and divestments, destabilisation and discontinuation are high on the agenda.

1.3 Studying technology beyond innovation

In the scholarly fields of innovation studies and science and technology studies, the emergence of technologies has traditionally been the focus of study. Even a decade ago Elizabeth Shove noted that '[w]ithin the fields of innovation studies and transitions theory, processes of emergence and stabilisation are better documented and more widely discussed than those of disappearance, partial continuity and resurrection' (Shove 2012: 363). Yet, the attempts to abandon undesirable technologies have been hampered by insufficient insights into how such processes unfold—whether they are deliberately pursued or not. The question of how technologies decline, which we are concerned with in this book, is timely and differs markedly from earlier questions about technology in society.

Of course, the recognition that technologies may be disruptive is not new. A century ago, the founder of innovation studies Joseph Schumpeter coined the phrase *creative destruction* to characterise the role of technical change in economies. Technologies do not just bring an accumulation of improvements, he argued, but will necessarily destabilise economic sectors, too. This still holds today: think about the woes of the postal services, which suffer from the popularity of e-mail. Before Schumpeter, Karl Marx analysed the exploitative and alienating nature of capitalism and its mobilisation of technology for this, and pointed to the fundamental disruption of social structures. The destructive character of technology, the destabilisation and eventual decline of industries or organisations, the social and

environmental costs of capital accumulation around technology and its use have a certain regularity and genericity that makes them observable in different geographical, sectorial or temporal settings.

The main starting point for this book is the observation that (desirable) exit or reduction objectives informed by critical discourses on technology are qualitatively different from fostering desirable innovation. They involve a different kind of phenomenon, requiring different skills, different interventions and different kinds of thinking: *decline is not just the reverse of innovation*. Moreover, deliberate decline is likely to face resistance from significant vested interests, which may be powerful incumbents as well as more vulnerable populations and communities facing to lose significantly from the end of systems they depend on. Deliberate decline entails significant challenges, such as those associated with regulating or restricting activities and livelihoods associated with 'undesirable' technologies, related political contestation and struggles, but also dealing with the fact that there will be winners and losers as a result of decline. Decline is likely to be as much about setting directions and objectives as it is about managing a process and handling its aftermath—including loss (Elliott 2018). The difficulty and, at the same time, opportunity is that technologies neither persist, nor disappear into oblivion automatically: they require work to do so (Callon 1987; MacKenzie and Spinardi 1995; Russell and Vinsel 2018). Moreover, formerly established systems may still be needed for very specific purposes (DDT for vector control, special purpose incandescent light bulbs, special purpose vehicles with internal combustion engines that are fossil-fuelled). At least for a transitional period, they may leave traces that outlive the discontinuation of their active use (e.g., dealing with nuclear waste long after the disconnection and dismantling of nuclear power plants) and require dedicated infrastructures. Sometimes they also threaten to come back as zombie technology because strong interests want to push them back into the market and effectively revert phase-out programmes (e.g., the revival of coal power generation) or critical discourses are shifting (e.g., nuclear energy framed as green and CO2-neutral or dirty and life-threatening). Thus, decline is neither a linear nor an irreversible process. This is new territory for policy and research alike, and calls for revisiting concepts, methods, capabilities and means for intervention.

1.4 Perspectives and concepts

This book proposes to ask what kind of processes are involved, what forms of decline can be observed, what lenses and concepts can be usefully applied and what questions remain unanswered. In this volume on technologies in decline, we seek to draw on a rich empirical base, which is diverse in terms of technologies, geographic locations and political settings. We intend to explore and use various intellectual starting points and concomitant concepts. The study of technologies in decline is necessarily *interdisciplinary*, drawing from multiple disciplines such as sociology, history, management and economics. Yet, this diversity can only be productive when there is also some common ground, which allows us to compare and contrast empirical findings and to connect conceptual claims.

Overall, the meta-theoretical lens of this book is *socio-technical* and we should clarify what this means, what it entails and what it requires. Firstly, 'socio-technical' refers to the insight that the social and the technical are deeply interwoven. They do not exist in separate domains, but are *mutually embedded* in tight relationships (Hughes 1983; Callon 1984; Latour 1999). As a consequence, socio-technical decline includes at least a partial dis-embedding of society-technology relationships. Secondly, a 'socio-technical' perspective implies that technological artefacts do not exist in and of themselves but only as a part of networks, configurations or systems. They can be seen as *configurations that work*, as Rip and Kemp (1998) phrased it. Consequently, technology removal or technology substitution is not the appropriate unit of analysis: technologies in decline is a matter of transformations in networks, configurations or systems. Finally, the socio-technical perspective points to the *interplay of social and technological dynamics*. The processes of technologies in decline then involve co-evolving social processes (political, cultural, psychological) and technical processes (in design, standardisation, manufacture, etc.).

The notions and terms mobilised in this volume showcase the varying foci and interests of its various contributors. Some of the notions point to emergent and long-term processes and mechanisms, such as 'destabilisation'. Others, such as 'discontinuation' or 'phase-out', help describe policy or policy goals and the related policy processes. Using past and contemporary examples, the contributions put forward different kinds of explanations, illustrate which strategies might work and which might not, and how decisions to turn away from a questionable technology could be initiated and navigated.

Judging just by the topics of the contributions and the theoretical constructs employed, we may sketch a preliminary frame of reference for various forms of technology decline, see Figure 1.1. The contributors of this volume are preoccupied with

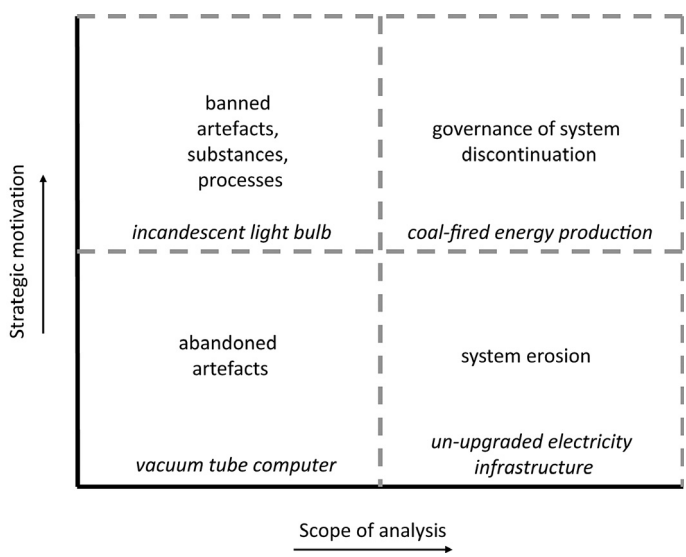

FIGURE 1.1 Varieties of technological decline

the particular processes of decline and adjacent concepts and how they unfold over time, their relevant characteristics, phases, trade-offs and dimensions. Two dimensions appear particularly relevant to make sense of the variety of perspectives: the scope of analysis (i.e., the perimeter of the technology, system or configuration in question) and the strategic motivations vested in a decline process (i.e., the extent to which decline is actively pursued or on the contrary a more emergent process). Of course, these dimensions are to be seen as gradients rather than binary categories, but they already allow us to qualify some archetypical foci along which *technologies in decline* are being thought up. Decline can range from the abandonment of a particular artefact or substance (say, a specific product model) or the erosion of a socio-technical system's relevance and centrality, to the more purposive ban of specific substances or products, or attempts to actively discontinue entire systems.

1.5 Outline of the book

We structure the volume in three Parts: from conceptual explorations, to empirical ones and, finally, to governance explorations. Table 1.1 provides an overview of the chapters, and bears witness to the significant variety of key notions deployed, analytical scale and contexts, focal context and primary research focus.

The conceptual Part of the book deals with three notions. The first one is decline, or *technological decline*, which in Zahar Koretsky's chapter is reconceptualised away from its colloquial, umbrella-term status in the book's title (and this introductory chapter) to a more specific and empirically supported characterisation: a measurable trend and a socio-material process of scaling down of production and/or use of a given product or process. In the chapter, Koretsky presents an overview of literature trying to understand the mechanisms of technological decline and offers, based on it, a socio-material characterisation. From a distinct conceptual starting point, Bruno Turnheim in his chapter focuses on the notion of *destabilisation* next to decline and phase-out. Destabilisation is understood as an emergent process of exposure of socio-technical orders to pressures significant enough to threaten their continued existence and 'normal' functioning, but also strategic responses of affected actors to this exposure and changing commitment to core productive engagements. Turnheim maps the theme of destabilisation in the transitions literature and proposes a research agenda. The third notion, central for Peter Stegmaier's chapter, is *discontinuation*, seen as a property of a technological trajectory in which its constituting relations become misaligned to such an extent that its distinctive character is lost, and also seen as a possible result of various permutations of distributed agency, contingency, emergence or deliberate governance. In this chapter we find a discussion of how the actions of groups of actors affect both the discontinuation of a trajectory itself and of governance practices that help stabilise it. These three notions—decline, destabilisation, discontinuation—provide lenses for the exploration of the problems around passive and active withdrawal of technologies from societies. As is discussed throughout the book and returned to in the Conclusions (Koretsky et al. 2023), these notions are interrelated and provide

entry points for dealing with the challenges that come with re-negotiating our relationships with technology.

A Part focusing on empirical studies continues the book's inquiry. To characterise their focal phenomena, some contributors have mobilised a range of additional notions and frameworks. Jochen Markard, Karoliina Isoaho and Linda Widdel (2023) study discursive destabilisation in a comparative setting, by examining framings of coal phase-out in mainstream press outlets across Europe. They adopt the conceptual lens of Technological Innovation Systems (TIS) to study the case of coal power generation in three countries. Daniel Weiss and Philipp Scherer (2023) mobilise the notion of 'phase-out' and approach it as an outcome of processes of decrease in production or consumption. They study the phase-out of the internal combustion engine also through the TIS framework, discussing the role of geographical context in phase-out and decline, focusing on divergent responses to phase-out pressures in the US and the EU. Frédéric Goulet (2023) studies decline as a process of innovation through withdrawal, and examines its relationship with processes of novelty creation. Using an illustrative case of bio-pesticides as alternatives to synthetic pesticides, his chapter explores how the development of substitutes can contribute both to the decline and continuity of problematic technologies. Dirk van de Leemput and Harro van Lente (2023) study the duality of decline of and care for a technology, framing care as 'aftercare' (cf. Stegmaier et al. 2014). Using the example of the 16 mm film as an object of art, they draw from museum studies and care studies. They show how actors can preserve and care for declining technology in pockets of resistance to decline, and how these processes are often invisible.

In the third Part of the book, we turn to governance-related perspectives. Adrian Rinscheid, Gregory Trencher and Daniel Rosenbloom (2023) focus on phase-out, which they see as a policy intervention for a stepwise decrease and termination of production or consumption of a product or process. They offer a systematic review of academic literature on the notion of 'phase-out' since the 1970s. They observe the changing attention to this notion in the literature and comment on the travels of this concept across environmental and societal challenges, policy efforts and instruments. The chapter by Ela Callorda Fossati, Bonno Pel, Solène Sureau, Tom Bauler, and Wouter Achten (2023) mobilises the concept of 'exnovation', where the authors seek to advance empirical knowledge on this notion adjacent to decline and discontinuation. The study focuses on the efforts of the Brussels-Capital region to establish and maintain a low-emission zone. The authors discuss political, jurisdictional and epistemic issues with the implementation of an exnovation policy, and highlight contestations and concomitant discourses of discontinuation in a complex governance setting. A captivating activist/academic testimony by Peter Newman (2023) on the end of leaded petrol complements the prior chapters with a powerful and, ultimately, hopeful account of, and reflection on, the possibility and reality of decline of an undesirable technology.

The concluding chapter by Zahar Koretsky, Bruno Turnheim, Peter Stegmaier, and Harro van Lente (2023) brings the three Parts together by returning to the

TABLE 1.1 Overview of the contributions to the present volume

		Core notions ○ Side notions •						Analytic scale			Focal context					Research focus					
Book section	**Book chapter**	Decline	Destabilisation	Discontinuation	Phase-out	Exnovation	Withdrawal	Domain	Country	Number of	Organisational	Municipal	Regional	National	Supranational	Transition	Governance	Innovation	Socio-technical	STS	Sectorial
Conceptual explorations	Koretsky	○			•			Energy, IT, Meteorology	USA, EU, RU	3	•			•	•	•			•	•	
	Turnheim	•	○		•			-	-	-	•		•	•		•			•		
	Stegmaier	•	•	○	•	•	•	-	-	-	•	•	•	•	•	•	•		•	•	
Empirical explorations	Markard et al.	○	•		•			Coal	UK, D, FIN	3	•			•		•			•		•
	Weiss & Scherer	○			•			Car	EU, JP, USA	1				•	•	•		•			
	Goulet	○		•				Agriculture, Pesticides	ARG, BRA	2				•		•		•			•
	Van de Leemput & van Lente	○						Media	UK	1	•									•	•
Governance explorations	Callorda Fossati et al.		•		•	○		Mobility	BE	1		•					•	•			•
	Rinscheid et al.				○			Sustainability	-	-				•	•	•	•				•
	Newman				○			Fuel	Several	1	•			•	•	•	•				•

question what the study of technologies in decline entails and requires. The chapter reflects on the progress made in this volume and delineates a research agenda for further study and reflection. In this way, with the book we hope to inspire more efforts to move to a next step in the relationship of current societies to technology as questions of *decline* become more prominent.

Note

1 The Intergovernmental Panel on Climate Change and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, both organisations of the United Nations.

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