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Broadening project studies to address sustainability transitions: Conceptual suggestions and crossovers with socio-technical transitions research

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ABSTRACT

Academic and socio-political interest in sustainability transitions, which are decades-long change processes in socio-technical systems, is rapidly increasing. To further engage with this topic, this essay suggests that project studies should continue its trend of conceptual broadening that has characterised the field in the past decade. Using the Multi-Level Perspective on socio-technical transitions as a meta-framework, this essay identifies and discusses the important roles of incremental improvement projects, exploratory projects, deployment projects, reorientation projects, and decommissioning projects in sustainability transitions. The essay also discusses crossovers with socio-technical transitions research and makes specific conceptual suggestions for broadening research on the different kinds of projects, programmes and portfolios.

1. Introduction

Project scholars are expressing an increasing interest in grand challenges including low-carbon transitions in energy, mobility, agri-food, and industrial systems, which are needed to mitigate climate change (Daniel, 2022; Gasparro et al., 2022; Ika & Munro, 2022; Ika et al., 2024; Koch-Ørvad et al., 2019; Morris, 2017; Sankaran et al., 2021; Winch, 2022). This poses a new challenge for project scholars because although there is relevant tradition and research on the sustainability *of* projects, often focused on integrating sustainability aspects during project delivery (Huemann & Silvius, 2017; Sabini et al., 2019), there is less research on sustainability *by* projects, i.e. the contribution of projects outcomes to large-scale system changes (Terenzi et al., 2024). We agree with Whyte and Mottee (2022) that many projects are "interventions in nature" that engage with the physical environment, causing changes with lasting consequences. Yet, we are only in the early days of this fresh perspective and Ika and Munro (2022: 601), for instance, diagnose that: *"too few and far between are the scholarly works devoted to project management and grand challenges."*

This dearth of research is understandable because grand challenges, including low-carbon transitions, have only become more prominent topics over the past decade, and because project studies have traditionally focused on more granular levels of analyses such as the firm and the project (Locatelli et al., 2023), even though there has been a broadening trend towards studying project ecologies (Grabher, 2004), project networks (Manning, 2010) and project lineages (Midler, 2013; Maniak & Midler, 2014), leading to what Geraldi and Söderlund (2018) call macro project studies. Low-carbon transitions and system change can be seen as a next step in this broadening trend, which will require some further reconceptualisation, as Geraldi and Söderlund (2018: 58) note: *"When looking at different levels of analysis, project scholars will develop alternative frames for projects, project practices and project studies."* In their editorial introduction to a special issue on bright and dark spots in project studies, Geraldi et al. (2021: 233) see sustainability transitions as *"an interesting future challenge for project studies"*, which may require *"close interdisciplinary collaboration (…) between scholars from, among others, engineering, project studies, organization studies, and social studies."* They also follow Davies et al. (2018) in suggesting that metatheories are useful to stimulate interdisciplinary project studies research and enable interactions with other fields.

To understand the various roles of projects in low-carbon transitions and propose avenues for conceptual broadening in project studies, we use the Multi-Level Perspective (MLP), initially developed in the sustainability transitions field (Geels, 2019; Geels et al., 2023a; Köhler et al., 2019; Smith et al., 2010) as a metatheory of large-scale system transitions. One reason for this choice is that the MLP is a flexible middle-range theory that has demonstrated its analytical usefulness and empirical validity through hundreds of empirical studies (Geels, 2024).

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Another reason is that project studies scholars have already started to constructively engage with the MLP (Daniel, 2022; Daniel & Daniel, 2023; Gasparro et al., 2022; Koch-Ørvad et al., 2019; Lenfle & Söderlund, 2022; Morris, 2013; Terenzi et al., 2024; Winch, 2022). Using the MLP as a metatheory, this essay will discuss the roles of projects in different phases of transitions and at different analytical levels: a) the emergence of radical innovation, b) the diffusion of niche-innovations, c) incremental improvement of the existing system, d) the ambidextrous reorientation of incumbent regime actors, and e) the phase-out of 'outdated' systems. For each topic, we briefly discuss what insights project studies already offers and suggest potentially fruitful extensions inspired by socio-technical transitions research and literature.

The essay is structured as follows. Considering the main greenhouse gas emitting sectors, Section 2 first suggests that projects will be important in low-carbon transitions because they act as vectors in the implementation and deployment of many low-carbon innovations (Terenzi et al., 2024). Section 2 also briefly presents the Multi-Level Perspective that will guide the subsequent sections. Sections 3, 4, 5, 6 and 7 respectively address the roles of projects in the emergence phase, the diffusion phase, incremental innovation, ambidextrous reorientation, and the decline phase. Section 8 concludes.

2. The pervasive role of projects in low-carbon transitions and the multi-level perspective

Although climate change is already happening with devastating effects, international goals like those in the 2015 Paris Agreement commit countries to limit the global average temperature rise to 'well below' 2 °C and to aim for 1.5 °C. Meeting these goals will require drastic reductions in greenhouse gas (GHG) emissions, which can only be achieved through *"rapid and far-reaching transitions in energy, land, urban and infrastructure (including transport and buildings), and industrial systems"* (IPCC, 2018: 21). Although global CO_2 emissions have continued to increase, they have started to *decrease* in Europe, the United States, and other high-income countries since the late 2000s (Fig. 1), mostly because of macro-economic shifts from industrial manufacturing to services and increases in renewable electricity, which reached 35.2 % of electricity generation in Europe (in 2022) and 22.7 % in the US (in 2023). Also, China, which as the largest CO_2 emitting country accounted for 31 % of global CO_2 emissions in 2022, appears to be approaching 'peak emissions' (CarbonBrief, 2024), partly because of increases in renewable electricity, which reached 30.7 % in China in 2023.

Although more needs to be done, low-carbon transitions are beginning to unfold in electricity systems (through renewables) and automobility systems (Geels, 2024). For the latter, battery electric vehicle sales in 2023 reached 38 % market share in China, 21 % in Europe, 9.5 % in the United States, and 18 % as the global average (IEA, 2024).

Global GHG emissions in 2019 were 59 $GtCO_2$-eq, of which 34 % came from energy production, 15 % from mobility, 6 % from buildings, 24 % from industry, 11 % from agriculture, and 11 % from Land Use, Land Use Change, and Forestry (IPCC, 2022). Although projects will also be important for adaptation (to make cities, public infrastructures, agriculture, and other systems more resilient to the consequences of climate change such as more extreme temperature, prolongated drought and more frequent floodings), the essay focuses on the role of projects in climate mitigation and the reduction of GHG emissions. Table 1 provides a breakdown of the main emitting sectors and identifies the main low-carbon innovations that are mentioned in multiple mitigation scenarios and can thus be considered to be 'robust'. The last column also shows that projects play important roles in developing and implementing many of the robust low-carbon innovations.

Having established the pervasive role of projects and programs in low-carbon transitions, we briefly present the MLP on socio-technical transitions to distinguish five generic roles of projects, which subsequent sections will elaborate in more detail. Rooted in evolutionary economics, the sociology of innovation and (neo)institutional theory (Geels, 2020), the MLP focuses on innovation as a driver of transitions and 'waves of creative destruction' (Schumpeter, 1942), but always discusses innovation in relation to actors in business, market, political and cultural contexts.

The MLP conceptualises large-scale transitions as multi-dimensional struggles between radical innovations, which initially emerge in small niches on the periphery of existing regimes (Kemp et al., 1998), and existing path-dependent systems; these struggles are shaped by wider exogenous context (or 'landscape') developments (Geels, 2002; Köhler et al., 2019; Smith et al., 2010, 2019). System transitions are usually decades-long processes that unfold through four different phases: 1)

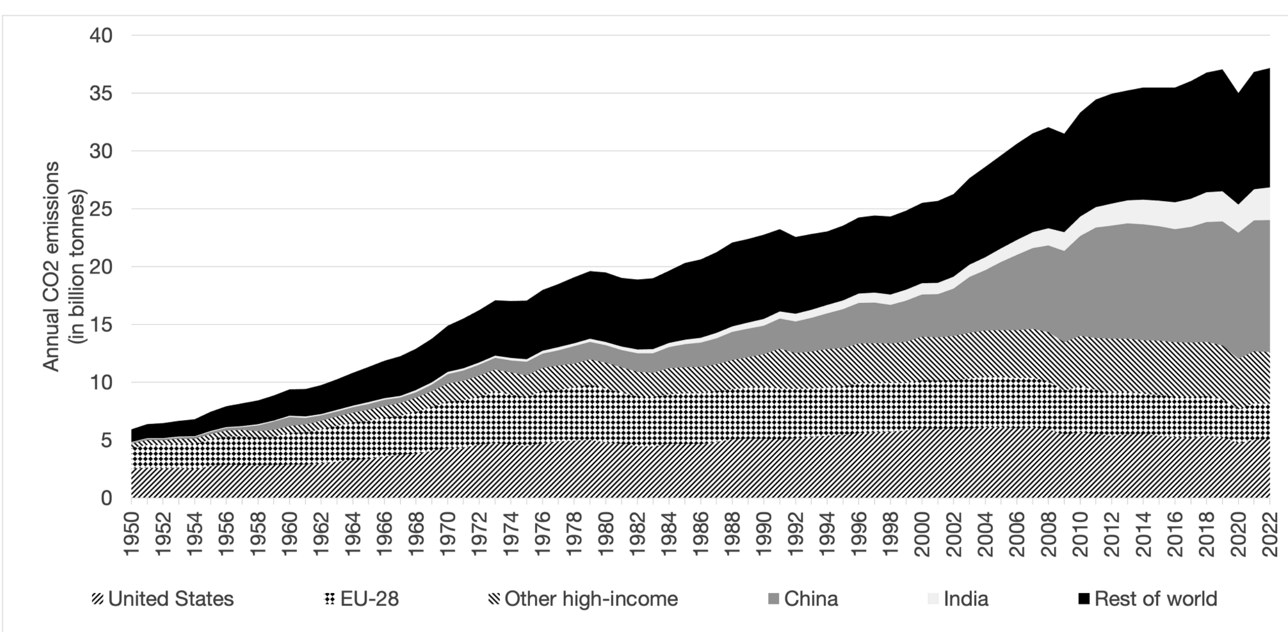

Fig. 1. Annual global CO_2 emissions (in billion tonnes) per region, 1950–2022 (constructed using data from Our World in Data; CO_2 and greenhouse gas emissions data explorer; https://ourworldindata.org/explorers/co2).

Table 1
Global GHG emissions from main sectors in 2019 (data from IPCC, 2022) and robust low-carbon technologies that appear in multiple climate mitigation assessments (ETC, 2021; IEA, 2021, 2023; McKinsey, 2022; Victor et al., 2019).

Sector	% of global GHG emissions	Robust low-carbon technologies	Pervasive role of projects
1) Energy production	34 %		
Electricity and heat generation (includes CHP)	24 %	- onshore wind - offshore wind - biomass - solar-PV - nuclear fission - energy storage	- wind turbines are usually organised in wind park projects; onshore turbines are sometimes organised as community energy projects; offshore wind parks are increasingly in the $billion megaproject range - solar-PV can be installed on domestic rooftops through millions of micro-projects (which take days/weeks to complete), but increasingly takes the form of utility-scale solar projects (which can cost $100 million or more) - bio-electricity generated in converted coal-fired power plants, which are large-scale industrial projects - fission nuclear power plants are large-scale megaprojects that in the EU and USA cost tens of $billions and take a decade to build (but are often more cost competitive in South Korea, China and Russia) - high penetration of intermittent renewables (solar, wind) will require large energy storage projects as essential "ancillary systems"
Other energy (e.g. oil refining, fugitive emissions from coal, oil, and gas production)	10 %	- decarbonise oil refineries (e.g., Carbon Capture and Storage (CCS), low-carbon hydrogen) - reduce fugitive emissions by reducing fossil fuel production and use	- hydrogen fuel switching or installing carbon capture on oil refineries are large-scale industrial projects, costing hundreds of $millions or more. - reduce fossil fuel use in transport (e.g. EVs), heating (e.g. heat pumps) and industry (e.g. hydrogen, electrification), which are further discussed below. - decommissioning of fossil fuel facilities and remediation of associated polluted land. - the reduction of methane emissions (from coal production, landfills, leaking pipelines) will involve diverse projects.
2) Mobility	15 %		
Road	10.3 %	- electric vehicles and vans (for passenger transport) - electric buses - electric or hydrogen-powered lorries	- EVs are commercial consumer-goods that can be purchased through markets, but also require a battery-charging infrastructure, which is created through projects (and programs) - switching bus or lorry fleets is usually organised as project or program, as it also requires on-site charging or hydrogen infrastructures.
Aviation	1.6 %	- hydrogen - biofuels - ammonia - synthetic fuels/e-fuels	all options in early development stage (R&D projects, pilot projects), creating high uncertainty. Airplane development typically organised as complex projects. Adoption and deployment by airlines organised as projects and programs (because they also involve changes at airports, including fuel infrastructure)
Shipping	1.6 %	hydrogen/ ammonia for long-distance shipping	tanker ship conversions are large-scale projects, while deployment would require programs to also transform ports and fuel infrastructures
Other	1.5 %		
3) Buildings	6 %		
Residential	3.9 %	- heat pumps and smart/energy efficient appliances and systems - insulation - solar thermal - district heating	- heat pump and other energy efficient systems installation, home insulation and solar thermal involve millions of domestic micro-projects (which take days/weeks to complete) - district heating involves local infrastructure projects that connect centralised heat generation (e.g., biomass boilers) with homes (which may also need new heat meters and radiators) through pipe infrastructures - adoption of structural timber in construction projects to replace concrete and steel
Non-residential	1.6 %	- heat pumps - insulation - district heating	*Idem* as for residential buildings (often

(*continued on next page*)

Table 1 (*continued*)

Sector	% of global GHG emissions	Robust low-carbon technologies	Pervasive role of projects
			through more bespoke projects)
4) Industry	24 %		
- Steel - Chemicals - Waste - Cement - Other	- 5.4 % - 4.7 % - 4 % - 2.7 % - 7.5 %	- CCS (carbon capture and storage) - hydrogen fuel switching - electric furnaces and boilers - hydrogen direct reduction of iron ore (to make iron)	- installing carbon capture technology, electric or hydrogen-ready furnaces and boilers involve complex retrofitting projects in industrial plants - low-carbon hydrogen production ('blue' or 'green') involves industrial projects to build new plants (and upgrade electricity grids or build CCS-systems) - CCS and (blue or green) hydrogen production also involve megaprojects to create new infrastructures systems (for transport and storage) - decommissioning of facilities that cannot be transitioned
5) Agriculture	11 %		
Enteric fermentation (livestock)	5.1 %	- low-emission feeds - alternative protein products	- millions of micro-projects by farmers, because feed switching also requires changes in on-farm feed delivery systems - veggie burgers and plant-based milk are New Product Development projects (NPD) that compete in markets
Managed soils and pasture	2.4 %	- resource efficient farming	- may involve farm-level projects such as new irrigation systems, automated feed systems, or satellite-based systems
Rice cultivation	1.8 %	- improved water, fertiliser and pesticide management	- adoption decisions and practice change by millions of farmers
Manure management, synthetic fertiliser application	1.3 %	- low-emission fertilisers (e.g. made from low-carbon hydrogen) - precision farming	- the creation of fertilisers from low-carbon hydrogen and ammonia require large industrial projects - precision farming requires farm level projects to implement ICT technologies and change farm practices
6) Land Use, Land Use Change, and Forestry	11 %	- afforestation	- tree planting projects and programs

experimentation in small technological niches through R&D, pilot and demonstration projects, which enable network building and learning processes with a variety of technical designs, 2) stabilisation of the innovation in a dominant design, which gains a foothold in small market niches, 3) diffusion into mainstream markets and head-on (multi-dimensional) competition with the existing system, and 4) overthrow and reconfiguration of wider systems, in tandem with the decline of the 'old' system (Fig. 2).

While the MLP already acknowledges the role of exploratory projects in the emergence of radical niche-innovations in phases 1 and 2 (Kemp et al., 1998; Schot & Geels, 2008), the novel contribution in Fig. 2 is to also distinguish other roles of projects such as deployment projects in diffusion, incremental improvement projects and ambidextrous reorientation projects at the regime level, and decommissioning projects in technological decline. This essay thus reconceptualises the MLP through a project studies perspective while also offering suggestions for conceptual broadening avenues in project studies with regard to the different kinds of projects. We define these different projects as follows:

- Exploratory projects are fundamental research & development (R&D), demonstration, or pilot projects that aim to reduce the many uncertainties associated with radical innovations by stimulating learning processes and new knowledge development (in the laboratory or 'real world') on multiple dimensions (e.g. technical performance, user preferences, social acceptance, infrastructure requirements).
- Deployment projects aim to build, install, retrofit, and operate technologies (or integrate technical components) to achieve predefined goals on time, within budget, and to agreed specifications, often (but not always) for clients.
- Incremental improvement projects are applied research and design projects that build on and extend existing knowledge and capabilities to enhance the performance or functionality of existing technologies (e.g. next generation products or designs) or develop more environmentally friendly manufacturing processes.
- Reorientation projects are vehicles for strategic efforts to shift incumbent firms towards new technologies, operational templates, and business models, often progressing gradually from tentative R&D towards pilots and demonstration projects, and then towards stronger commitment and deployment.
- Decommissioning projects are projects that dismantle capital-intensive assets at the end of their life to avoid risks, reduce potential pollution, or make the site available for new uses.

Subsequent sections will elaborate on these different kinds of projects and offer conceptual broadening suggestions.

3. Exploratory projects in the emergence of radical niche-innovations

Radical innovations, which in phases 1 and 2 emerge in small niches peripheral to the existing system, are initially characterised by many uncertainties, including about technical designs (as there is often a variety of competing designs), future cost and performance, who the users might be and what their preferences are, infrastructure requirements, policy support, cultural meanings and social acceptance (Kemp et al., 1998). Both the transitions literature (Schot & Geels, 2008; Sengers et al., 2019) and the project studies literature (Frederiksen & Davies, 2008; Lenfle, 2008, 2016; Lenfle et al., 2019) therefore emphasise the role of exploratory projects, pilots, experiments, and demonstration projects to enable learning and articulation processes that can gradually reduce the uncertainties and improve the radical innovation in the emergence phase.

The project studies literature also usefully highlights that these projects tend to be organised in programs (Kopmann et al., 2017; Martinsuo & Hoverfält, 2018), which can take the form of chains, portfolios, or networks (Maylor et al., 2006), and that these programs can be managed in different ways which place varying degrees of emphasis on selectionism (i.e. try multiple options and keep the one that works best) and sequential learning between projects (Loch et al., 2006; Pich et al., 2002). Elaborating the exploratory and sequential management styles, the multiproject lineage management (MPLM) approach (Kock &

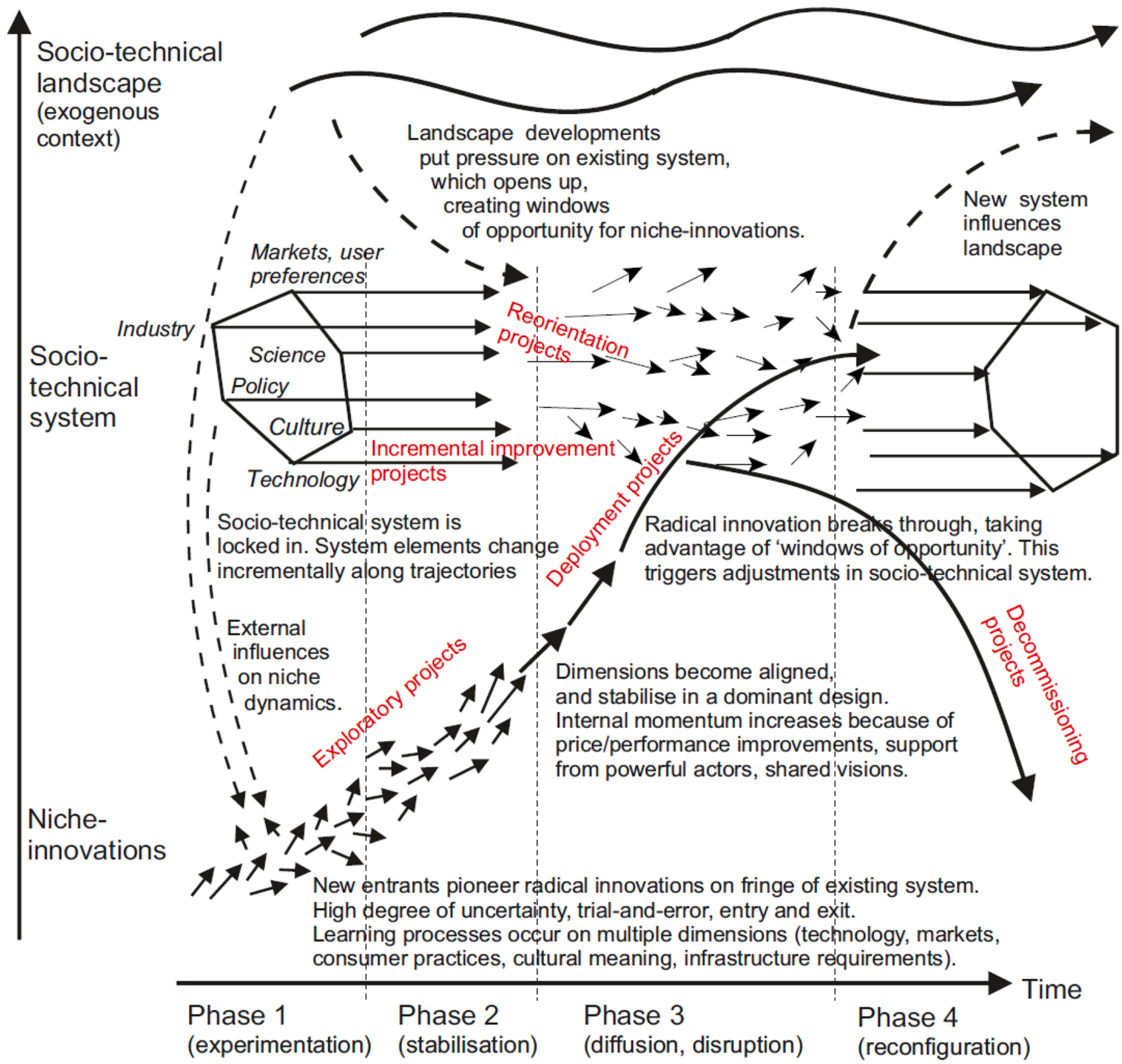

Fig. 2. Distinguishing various roles of projects (in red) in the Multi-Level Perspective on socio-technical transitions (adapted from Geels & Turnheim, 2022).

Gemünden, 2019; Midler, 2013; Maniak & Midler, 2014) further offers an important way to analyse emerging niche-innovations as longitudinal trajectories that are constituted by lineages of projects driving cumulative learning processes and sequential improvements.

But since many of these significant project studies contributions remain focused on firms and project organising, there is a need for conceptual broadening if one wants to analyse technological innovation and sustainability transitions, which are multi-dimensional processes (Bijker & Law, 1992; Geels et al., 2023a; Köhler et al., 2019). Drawing on the Strategic Niche Management (SNM) approach (Kemp et al., 1998; Schot & Geels, 2008), which combines ideas from evolutionary economics and the sociology of innovation, we specifically suggest that project studies should more explicitly conceptualise knowledge-related interaction processes between projects, organisations (Chen et al., 2022) and organisational fields to better capture that the development and stabilisation of technological knowledge happen not just within firms but also at the level of organisational fields.

A case in point are Austrian Biomass District Heating (BMDH) systems, which emerged in the 1970s through pioneering projects by dispersed sawmill owners, carpenters, and monasteries, who burned wood residues to generate heat that was then provided to nearby houses through pipe infrastructures. The outcomes of these early projects, which emerged without dedicated R&D or formal knowledge, were often inefficient and encountered significant problems (Geels & Johnson, 2018). In the early 1980s, entrepreneurial pioneers became aware of each other's projects and formed networks to exchange experiences. By the mid-1980s, farmers, who in Austria often own forests, started projects to build BMDH-systems to commercialise wood products, leading to more and larger projects. Regional policymakers became interested because of rural revitalisation opportunities, and the newly created Austrian Biomass Association started organising workshops, comparing local experiences, and formulating generic lessons. Boiler suppliers also became involved while university departments started research projects to improve BMDH-system performance, leading to the articulation of more codified field-level knowledge (Geels & Johnson, 2018). Benchmarking and quality control activities by regional energy agencies also helped to codify knowledge, which they subsequently disseminated through capacity-building projects such as training and technical advisory services.

Knowledge development for Austrian BMDH-systems thus involved (sequences of) projects, multiple organisational levels (organisations, networks, and organisational fields), and various kinds of activities. While project scholars have recognised these different organisational levels in relation to projects (Grabher, 2004; Manning, 2008), the SNM approach has arguably further conceptualised interactions between these levels over time and in relation to emerging niche-innovations.

Because of its primary focus on emerging technologies rather than projects or firms, the SNM approach starts with an understanding of technological innovation as a social process (Bijker & Law, 1992) that is enacted by multiple actors (including firms, users, policymakers, wider publics) who over time develop a dedicated community or organisational field (e.g. the solar-PV or wind energy field) with stabilised institutions and rules (including for knowledge). The SNM approach also acknowledges the importance of local projects (e.g. R&D, pilots, demonstration projects), which it understands as the carriers of emerging technologies that enable real-world learning processes and interactions and collaborations between actors (which can create enduring social networks). Like the MPLM approach in project studies, SNM scholars conceptualise niche development as a *sequence* of local projects (Fig. 3), but additionally emphasise circulation and aggregation processes.

Early projects tend to be exploratory and directionally diffuse because field-level knowledge and institutions are initially underdeveloped and fuzzy. The subsequent circulation of people and experiences between projects and dedicated aggregation activities then gradually help to articulate problem agendas, search heuristics, best practices, and technical models, which stabilise a cumulative innovation trajectory (Cowan & Foray, 1997; Geels & Deuten, 2006). The creation of a dedicated community with intermediary actors (like professional associations or engineering societies) who engage in aggregation activities as well as the creation of a knowledge infrastructure (such as dedicated journals, conferences, and workshops), which help to share and disseminate knowledge and experiences, are important socio-cognitive processes in the development and stabilisation of new technical knowledge (Geels & Deuten, 2006; Kivimaa et al., 2019).

This conceptualisation of projects, lineages, organisational fields, knowledge sharing and aggregation activities in emerging niche-innovations is a promising avenue for broadening the project studies research agenda.

4. Deployment projects in the diffusion of radical innovations

The sustainability transitions literature often conceptualises technological diffusion as a market-driven adoption process, in which end users purchase products from firms (Rogers, 1996; Winch et al., 2023). While this is correct for mass-produced consumer goods (e.g. electric vehicles), many low-carbon capital goods (e.g. power plants) diffuse through the implementation of projects, as indicated in Table 1. Large-scale (mega)projects are especially salient in electricity production (e.g. utility-scale wind and solar parks, nuclear power plants), industry (e.g. CCS, electrification, hydrogen production and hydrogen fuel switching), and mobility (e.g. battery gigafactories and battery recharging infrastructure, ships and ports, aeroplanes and airports). The roll-out of many micro-projects (in the order of thousands of $USD, e.g. solar photovoltaic rooftop) is salient for buildings and small farms, because the installation of heat pumps, insulation, solar thermal, or rooftop solar-PV requires homeowners or farmers to hire contractors or builders to install the technologies. For large and complex buildings (e.g. the UK Parliament) or massive farms, the projects are bespoke and can cost hundreds of thousands of $USD or more.

Sustainability transitions scholars can thus glean relevant insights from the project studies community, which is already beginning to happen (e.g. Geels et al., 2023b; Papachristos et al., 2024; Papadonikolaki et al., 2023; Turnheim & Geels, 2019). While cost reductions through learning curves are well-known for commodity products (Arrow, 1962; Yelle, 1979), project studies scholars (Davies & Brady, 2000; Mignacca & Locatelli, 2020) extended it to more complex products and systems, suggesting that costs per project are initially high but decrease over time (Fig. 4) because firms and project networks develop specific 'project capabilities' as they transfer experiences from the first project (stage 1) to succeeding projects (stage 2), functionally reorganise organisations to create specialised groups and teams for particular projects (stage 3), and create new business units or product divisions (stage 4). The shift from exploratory projects in stage 1 towards more 'repeatable' project deployment solutions (including stabilised designs and efficient supply chains) in stages 2, 3 and 4 thus helps to reduce costs and accelerate delivery times, which drive diffusion.

These deployment project processes and associated cost reductions may, however, not apply equally to all kinds of technologies. The typology by Malhotra and Schmidt (2020), which distinguishes technologies in terms of design complexity (i.e. number of sub-components of a technology and degree of modularity) and need for customisation (i.e., adjustment to user environments), is relevant in this regard (Fig. 5). Building on this typology, we suggest that projects with type-1 and type-2 technologies, which have limited or medium complexity and customisation needs, are more likely to experience significant cost reductions as deployment shifts towards 'repeatable' solutions than projects with type-3 technologies, where high complexity and high customisation needs may preclude standardisation and repetition, requiring projects to be more bespoke, unique and tailored to specific contexts.

The deployment processes proposed by Davies and Brady (2000) clearly describe the deployment of offshore wind in the UK (Geels & Ayoub, 2023; Kern et al., 2014), which is a type-2 technology. The UK has become a world leader in deploying this technology, generating 17.0 % of its electricity from offshore wind in 2024 (TCE, 2024). UK offshore wind development started with six successive exploratory projects in the 2001–2007 period, which stimulated learning processes and the creation of a technological community. Although offshore wind was long perceived as unfeasibly expensive, policymakers doubled financial

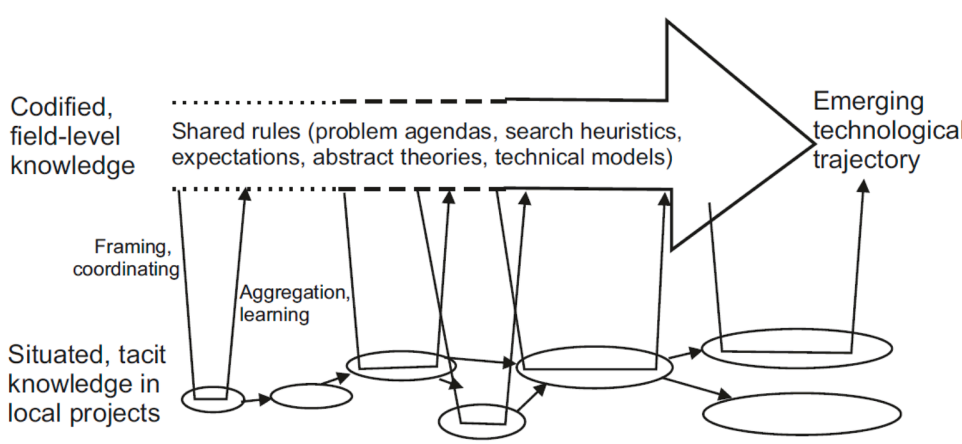

Fig. 3. Niche-innovation trajectories as carried by local projects and advanced by field-level aggregation activities (Geels & Raven, 2006: 379).

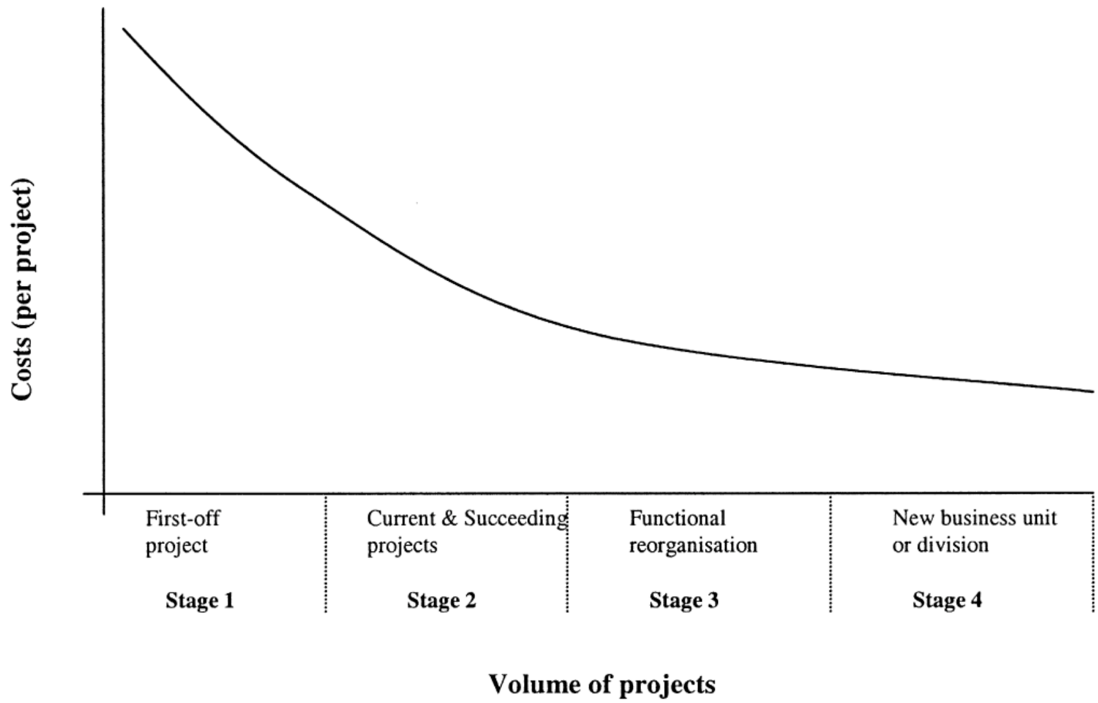

Fig. 4. Project delivery costs decrease as firms gain more experience (Davies & Brady, 2000: 941).

support in 2009 (Geels & Ayoub, 2023), which drove rapid subsequent diffusion. While the Levelized Cost Of Electricity (LCOE), which captures the average net present cost over the technology's lifetime, remained relatively high for offshore wind until 2014, it decreased by 65 % after 2015 as three successive auction rounds (in 2015, 2017, and 2019) for Contracts for Difference (CfD) drove a stream of successive offshore wind park projects with increasingly lower strike prices.

Learning-by-doing processes and the improvement of organisational and project delivery capabilities were clearly one of the contributing factors to cost decreases (Carbon Trust, 2020), confirming the validity of project studies insights. But the cost decreases and diffusion process are also related to broader socio-technical system factors (Carbon Trust, 2020; Geels & Ayoub, 2023) such as a relative shift in the manufacturing of wind turbine components from Europe to China (lowering cost because of scale economies in production, lower labour cost, and less stringent environmental standards), a technological trajectory towards larger wind turbines (which generate power more efficiently), decreasing cost of capital (as financiers gained experience with offshore wind farm funding, leading to lower risk perceptions), and the policy change (in 2013) towards an auction scheme for CfDs (which stimulated competition, reduced market risk, and led to lower bids as firms gained more experience with offshore wind).

The conceptual implication for project studies is that analyses of the diffusion phase should arguably not only address firm-level project delivery processes, but also investigate wider niche and regime-level contexts, including broader developments in technology, policy, industry, markets and arguably also societal debates (Fig. 2). These developments, in turn, can be influenced by wider landscape shocks such as Russia's war on Ukraine and the resultant 2022–2023 gas price crisis, which increased inflation and interest rates that, in turn, raised costs for building offshore wind parks (leading some renewables companies like Ørsted to exit agreed UK projects in 2023). Project scholars could thus benefit from paying more attention to wider context influences at the landscape level.

This suggestion aligns with critical diagnoses from project scholars about the frequent treatment of institutions and policies as background conditions. Morris and Geraldi (2011: 24), for example, complained that *"the institutional context of construction projects is treated as largely given"*, while Winch (2017: 346) similarly diagnosed that government *"at best, lurks in the background of most analyses"*. For low-carbon transitions, in particular, it is essential to include policies and government institutions in the analysis of projects, because climate change is an externality that most project actors would otherwise not address. Political power struggles and public debates are also important in this regard as they can create setbacks or windows of opportunity for the deployment of ambitious projects, but, unfortunately, we do not have the space to further address this here.

5. Incremental improvement projects in existing systems

Sustainability transitions scholars rarely study incremental changes in existing socio-technical systems because these are understood as resulting from routine-driven search behaviour in well-known technology spaces. The implicit assumption is that incremental improvements are easy, commonplace, and uninteresting. The relative neglect of this topic may also have a normative reason, namely that transition scholars often frame the existing system as unsustainable (and thus 'bad') and thus do not want to analyse incremental changes that can improve the existing system, thereby delaying or hindering more fundamental system transitions.

Project scholars have also limitedly investigated how projects can contribute to incremental innovation trajectories (Berggren, 2019). Nevertheless, the project lens can be analytically useful to 'open up' the concept of incremental path-dependent technological trajectories. In particular, the project lens suggests that incremental product improvements at the firm or interfirm level are often organised as projects, even open innovation projects (Greco et al. 2021; Locatelli et al. 2021), which are carried and enacted by temporary teams that have targets and work with constrained schedules and resources to obtain deliverables. Detailed ethnographic analyses of incremental product upgrades like the next version of micro-computer (Kidder, 1982), the next version of automobile (Halberstam, 1986), or the next version of fighter aircraft (Law & Callon, 1992) have shown that these projects can be non-linear, contested within the firm (or wider network), risky and prone to failure.

Both single projects, programmes and sequences of projects (leading to lineages) can thus be analysed as contributing to incremental

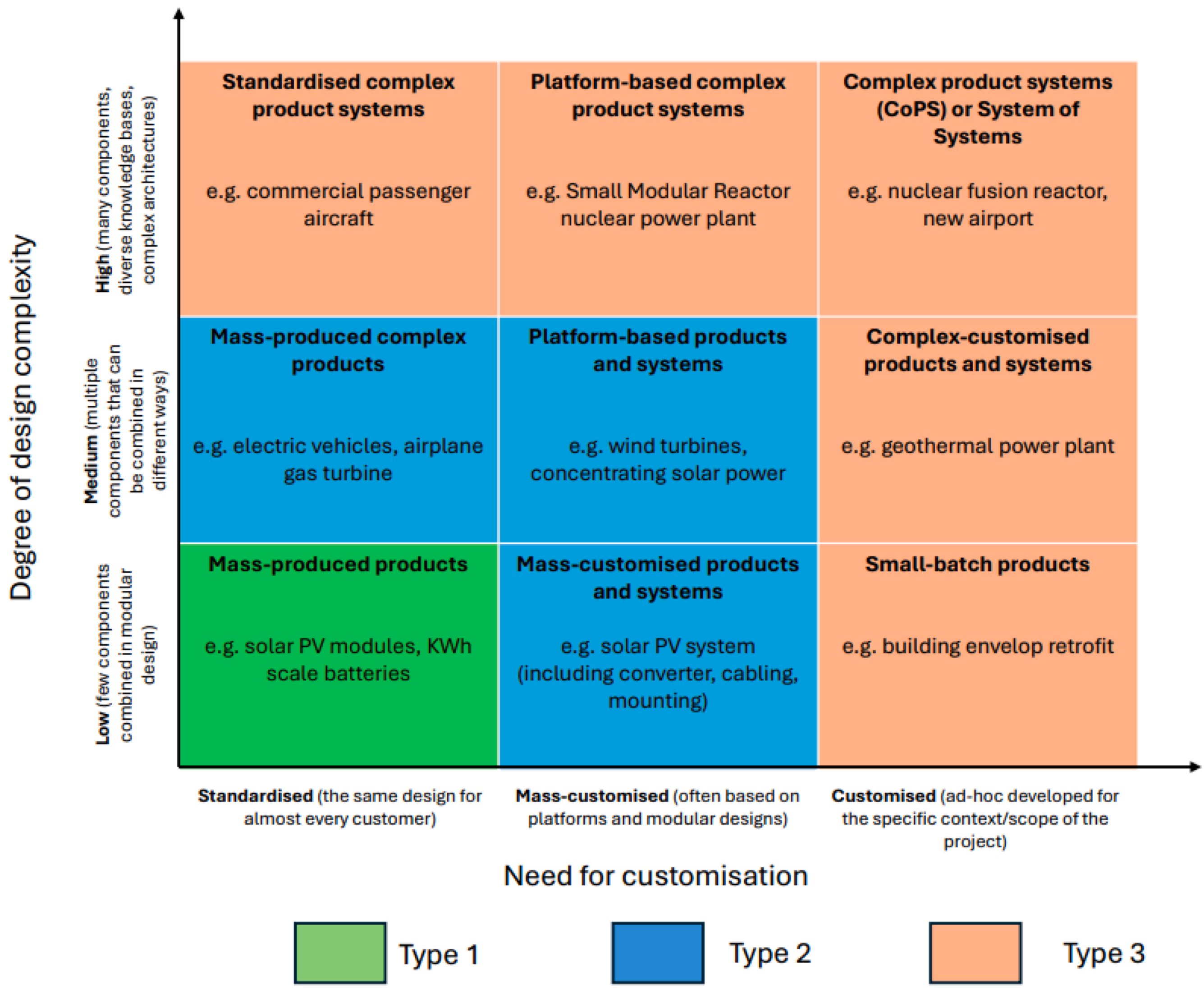

Fig. 5. Characterizing energy technologies according to their design complexity and need for customization (adapted from Malhotra & Schmidt, 2020: 2261).

improvements in existing socio-technical systems. The potential relevance for analysing sustainability transitions is that the number and financial investments in incremental improvement projects can be seen as indicators of the degree to which incumbent actors are still committed to the existing socio-technical system. If incremental project numbers and investments are high, then incumbents are more likely to defend the existing system and resist sustainability transitions.

6. Reorientation projects by incumbent firms in existing systems

Projects are also important in the reorientation of incumbent firms, which the sustainability transitions literature (Bergek et al., 2013; Berggren et al., 2015) increasingly recognises as important since the development and diffusion of low-carbon innovations in electricity, industry, mobility, and agriculture will likely involve incumbent firms that reorient from fossil fuel regimes to emerging niche-innovations. Low-carbon reorientation is not easy, because incumbent firms tend to be locked-in to existing systems and regimes. Significant reorientation therefore typically involves increasing pressures on firms from socio-political environments (e.g. public debates, climate policies) and economic environments (e.g. suppliers, customers, foreign competitors). As context pressures increase, incumbent firms often reorient reluctantly through five different stages (Geels & Gregory, 2023; Gregory & Geels, 2024): 1) denial or contestation of the problem (e.g. questioning the climate science), 2) accept the problem but implement *incremental improvement projects* to defend and enhance the existing system (e.g. efficiency improvements), 3) investigate more radical alternatives (through *exploratory projects*), while continuing to exploit existing assets ('hedging', 'ambidexterity'), 4) start using low-carbon technologies through *early deployment projects*, while 'milking' the old assets ('diversification'), 5) full reorientation to low-carbon technologies through *large-scale deployment projects*, including changes in core strategy and mission.

Project studies scholars have also recognised the importance of projects as vehicles for incumbent reorientation and ambidextrous management (Berggren, 2019; Lenfle & Söderlund, 2022; Midler et al., 2019; Pellegrinelli et al., 2015), but transition studies research arguably contributes a richer conceptualisation of temporal unfolding and different roles of projects in successive reorientation phases. A further contribution from sustainability transition studies is that projects do *not* always imply a genuine desire to reorient by firms, which sometimes seems the implicit assumption of project studies. In fact, firms can also strategically use projects to hamper or delay significant change. In the second reorientation phase, for example, firms can implement incremental projects to delay regulatory change, arguing that climate regulations are not needed since they are 'voluntarily' already addressing the problem (Penna & Geels, 2015). For example, a project to develop a more efficient diesel engine can be used to argue against electrification of the automotive sector. And in the third reorientation phase, firms can use exploratory projects (e.g. R&D, pilots) to create the impression that they are reorienting without having real intentions to later deploy the innovations (Turnheim et al., 2018).

A final conceptual contribution to project studies is that the influence from projects on wider corporate sustainability strategy (through learning, sense-making, and strategic reorientation) may in the second and third phase be weaker than external landscape changes (e.g. the 2007/8 financial crisis leading to weakening climate regulations and diminished low-carbon reorientation strategies) that can lead to strategic reversals to earlier phases and the downscaling of exploratory projects (Geels & Gregory, 2023).

7. Decommissioning projects in the decline of existing technologies

The sustainability transitions literature has also started to investigate the destabilisation and decline of existing technologies and systems, which is often analysed as the result of the inability of incumbent actors to adjust to increasing context pressures and changing (techno-economic and socio-political) environments (Koretsky et al., 2022; Rosenbloom & Rinscheid, 2020; Turnheim & Geels, 2012). The transitions literature has paid less attention to the role of decommissioning projects, which may be especially relevant for capital-intensive assets (like oil platforms, nuclear plants, or industrial plants) and consumer products (e.g. asbestos rooftop removal) that need to be dismantled with care, which requires dedicated expertise and may be expensive (in the order of hundreds of millions for large complex assets).

Although this topic is relatively understudied in project studies, an emerging stream of literature has begun to investigate it (e.g. Invernizzi et al., 2017, 2020). It, firstly, finds that decommissioning projects are often controversial because the termination of an asset that generates services and revenues leads to job losses and (local) economic damage. This applies both to the project level (e.g. decommissioning a single nuclear power plant) and the national/sector level (e.g. phasing out nuclear power in a country). In the latter case, it is important to maintain sufficient workers, skills, and supply chains for decommissioning projects. Secondly, the need for decommissioning projects may be contested and involve conflicting considerations. An aging dam, for example, produces electricity with minimum marginal environmental and economic cost, but deteriorating concrete, sediment deposits and widening micro-cracks increase the risk of collapse. Assessing the need for decommissioning (or major repairs) involves the need to balance the risk of a catastrophic collapse with the marginal production of clean electricity. Thirdly, decommissioning projects are often linked to political decisions that affect multiple plants (as for nuclear phase-out decisions). Fourthly, decommissioning projects may require innovations in machineries for site characterisation (e.g. to map radioactivity or chemical contamination), processes and procedures for plant dismantling, approaches to treat and store waste, and approaches to site restoration.

8. Conclusions

This essay has shown that projects and programmes are essential vectors for low-carbon transitions (Terenzi et al., 2024), because many low-carbon technologies are being developed and implemented through projects. Low-carbon transitions thus form a fruitful research area that project studies scholars have started to engage with. Because low-carbon transitions are long-term, system-level change processes on multiple dimensions, involving firms as well as multiple other actors, this essay has argued that project studies would benefit from further conceptual broadening to investigate this topic. Using the MLP from sustainability transitions research as meta-framework, the essay has distinguished different roles of projects in transitions, including for incremental improvement, exploration, deployment, reorientation, and decommissioning. We identified crossovers with transition studies and made specific suggestions for potential conceptual broadening. We hope that project scholars find these suggestions useful and will expand, deepen, and broaden their research on sustainability transitions and grand challenges in the coming years.

Additional to these suggestions, we propose that the following research avenues are interesting and worthwhile. One avenue is to investigate broader kinds of projects that go beyond the 'tangible projects' like power plants, new engine design, or building retrofits that were the focus of our essay. One could think of 'behavioural intervention projects' (Terenzi et al., 2024) that aim to change consumption patterns (e.g. campaigns to convince people to take public transport instead of cars) or 'socio-political projects' by NGOs (which also take the form of time-limited teams, resources, and targets as in 'normal' projects) to shape public debates or policies around technologies like coal-fired power plants. Another avenue is further investigation of the effects of wider context changes on projects, for example through developing broader understandings of project success (e.g. Ika & Pinto, 2022). The MLP's landscape level may be useful to consider and further conceptualise in this regard. A third important avenue is the investigation of projects and sustainability transitions in emerging economies, which face particular challenges such as higher costs of capital (which increases the cost of large-scale wind or solar farm projects), less developed supply chains, skills, or repair facilities (which complicate construction and maintenance), and corruption and political instability (which increase project risks). Fourthly, project scholars should not only be concerned with theory but also with the actual implementation of projects. In particular, it would be helpful for practitioners if scholars could better indicate if or how the management of 'transition projects' differs from other projects. Maybe these differences are less about the delivery model, and more about the front end of projects, including the 'business case'? Maybe changes are needed in the Project Charter? Or maybe new or updated planning and delivery tools are needed? Scholarly work and reflection on these kinds of more practical issues could be very useful for the millions of projects professionals who change the world through the projects they implement on a daily basis.

CRediT authorship contribution statement

Frank W. Geels: Writing – original draft, Visualization, Investigation, Conceptualization. **Giorgio Locatelli:** Writing – original draft, Investigation, Conceptualization.

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