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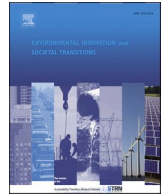
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The role of design in sustainable transitions: The case of mobility in Greater Copenhagen

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ABSTRACT

This article is an exploration of the role of design in sustainability transitions. Design has the potential to complement discussions on governance and actions related to transitions in the making, and activate scholars' ability to critically assess existing technologies, technological components and systemic relations, and their capacity to propose alternatives. The authors draw on their engagement with the project 'A Coherent Transport System for Greater Copenhagen 2050', and on visioning for Copenhagen's future, with a special emphasis on discussions on mobility. The primary claim is that design can have a pivotal role in destabilizing existing regimes and creating systemic alternatives and transformative technologies and components. We propose a framework that focuses on three elements: the position of designing; integration across levels of design; and design-based criticism of the existing 'de-scriptions' to create new designs or 'in-scriptions'.

1. Introduction

This article explores the role of design in sustainability transitions scholarship. We propose a framework that incorporates insights from design to study the current system and aspects of future possible systems that actors are attempting to put in place to enable a transition to sustainability. We exemplify our proposal with the case of mobility in the Greater Copenhagen Region (henceforth GCPH). The motivation is twofold: to complement transition discussions on governance which, although geared to support transitions in the making, tend to focus on processes and context; and to activate the technical capacity of transition scholars, who are engineers and designers, to assess the technologies, technological components of systems and technological relationships from a sustainability transition point of view.

We draw on the case of mobility for Greater Copenhagen which is a bi-national region comprising the east of Denmark and the south of Sweden. In this region, there is tension between actors committed to maintaining the current car-based transportation system and those with visions of a sustainable system, as well as plans, designs, and socioeconomic calculations to substantiate them. Drawing on the engagement of two authors of this article on the project 'A Coherent Transport System for Greater Copenhagen 2050' (henceforth the Interreg project) (Greater Copenhagen, 2021), and Martin (2021), we illustrate these dynamics with a focus on component and product, system and governance, generating insights to reveal critical efforts towards the existing scenario and innovations, and presenting the position of design.

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This article is organized as follows. [Section 2](#) is a discussion on design in sustainable transitions. In [Section 3](#), we present the methodology we followed. In [Section 4](#), we explain how design plays a role in maintaining the current dominant car system, challenging the established system and structuring sustainable alternatives. We discuss the implications for sustainability transitions in [Section 5](#), and conclude in [Section 6](#).

2. Design in sustainable transitions

In this section, we present three elements for our analysis: first, our framework to analyze design in transitions; second, a review of what has been published in sustainable transitions and design in general; and third, a review of what has been covered on design in the *Environmental Innovation and Societal Transitions* journal.

2.1. Position of designing, de-description/in-scription, levels of design

In his seminal work, Victor [Papanek \(1972\)](#) asserted that design is a fundamental aspect of human activity, stating that "all that we do, almost all the time, is design" ([Papanek, 1972](#), p. 3). This points to the fact that since we all do design, it is necessary to reveal and analyze where design-based critiques or new designs come from. We call this the position of designing.

[Young \(2008\)](#) defined the goal of design as not only describing regularity, but also offering solutions to culturally based problems (p. 566). This suggests that a design is not only a new proposal, but also a critique of the existing scenario. Madeleine Akrich's *Description of Technological Objects* ([Akrich et al., 1992](#)) uses analytical language to explain this pairing of critique/proposal. She says what is in-scribed in existing designs (in-scriptions) needs to be questioned: a process of de-description. This enables a process of creating new scripts (re-in-scriptions) which are new designs. We propose that a second aspect to activate design is to reveal how innovations imply critique and vice versa.

[Andreasen et al. \(2015\)](#) portray design as the *idea in the design* (the inner workings) and the *idea with the design* (the context of operation). In other words, design research theorists are aware that designing products, services, or systems involves taking care of their technical content, and also creating their contexts, and vice versa. [Young \(2008\)](#) proposes that the design of concrete products, configurations, technical details, and components is design within a context that is given; designing at the level of systems thinking is designing context; and designing at the level of policy formation and ideology is design of context, as shown in [Fig. 1](#).

Most of the transitions community work focuses on a) issues that Young defines as 'designing context' (system) and how businesses and organizations can contribute to transitions; and b) aspects of governance, understood as interactions among public and private organizations interested in solving societal problems, or creating societal opportunities ([Köhler et al., 2019](#), p. 8). In Young's design framework, this is the 'design of context' (governance).

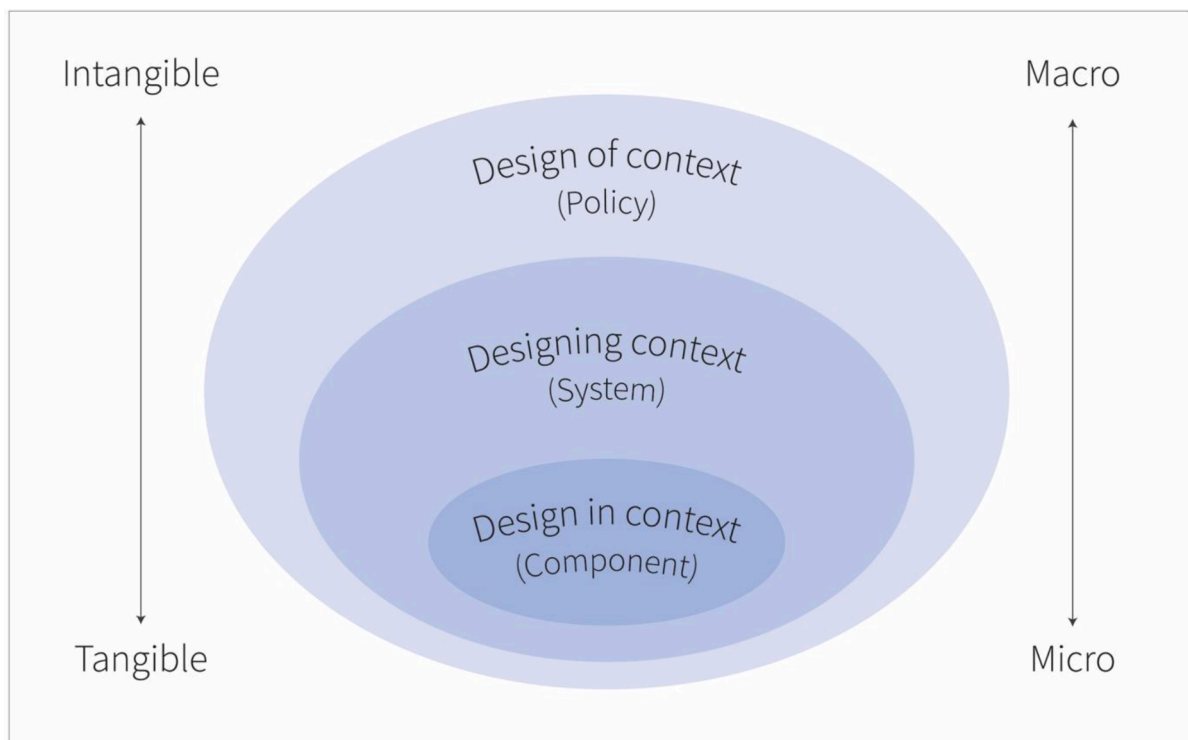


Fig. 1. World-view model of levels of design content based on [Young \(2008: p. 571\)](#).

The sustainability transitions approach concentrates on key process dynamics within and among organizations. Exemplary approaches are Transition Management and Strategic Niche Management that either provide a framework for diagnosing systemic deep-rooted problems (Loorbach, 2007; Rotmans et al., 2016; Hebinck et al., 2022) or start the observation of dynamics once there is an alternative to the incumbent (Geels, 2005; Schot and Geels, 2008). What we miss on many of these is the relationship to the ‘design in context’. In this article, we claim that this insight should be activated systematically in the transitions scholarship, not only by analyzing context, which is standard practice, but also by analyzing and unpacking the relationships within, and to the designed objects. In other words, we propose to improve our capacity to describe, analyze and intervene in the way Young’s three levels are connected.

2.2. Sustainability transitions and design

Recently, a strand of literature has emerged in the United States under the banner of transition design (Irwin, 2015, 2022), which considers how to incorporate insights from sustainability transitions in industrial design. In Europe, there is another strand presented by Ceschin and Gaziulusoy (2016; 2019) who provide a complete overview of different approaches to design for sustainability, with their origins, strengths, and limitations. There are detailed and informed proposals on how to create services and product service systems which have the potential to decouple increased access to services from increased demand on materials (Ceschin, 2013), and how to integrate different traditions of design and sustainable transitions in a robust multilevel model that addresses grand challenges (Joore and Brezet, 2015). Gaziulusoy and Öztekin (2019) conduct an analysis of the role of designers in sustainability transitions. They conclude that designers should transcend their roles in “incubation, experimentation and implementations at the niche level” and should engage in processes of “acceleration and scaling up of alternatives” (p. 11). All these valuable efforts, published in design journals, concentrate on activating sustainability transitions insights to improve design knowledge, theories, and methods.

One noteworthy contribution is by Gaziulusoy and Brezet (2015) who discuss how to integrate sustainability science, systems innovations, and transition theories into a proposed method which could be applied by companies. They consider that design teams in companies have little room for dealing with sustainability and systemic considerations, while in strategic discussions design is often overlooked. In other words, companies tend to address contextual policy issues, sustainability, and product design in a disintegrated fashion. They propose addressing these challenges by creating opportunities for integration among actors (product development team, company, and society) and expanding the time frame of design efforts. Concretely, they propose a shadow track strategy to harmonize the work of design teams delivering solutions for surviving under existing market conditions, while at the same time addressing changing societal and systemic developments. This requires the double movement of making explicit the influence path from existing social dynamics that is realized in normal products, and the feedback path by which products inform societal change. The first one is compatible with strategically considering socially desirable objectives on sustainability in processes of design, by folding back general objectives into strategic company aims, and into requirements from product design. The second is more akin to the progression of product improvement to product redesign to function innovation and system innovation, which is a more popular expectation and mode of operation for companies. The main point is that context and design need to be integrated. And this is compatible with our suggestion of integration strategies among Young’s levels of design while addressing symmetrically critique (de-scription) and creation (in-scription), and making explicit the position of designing. Gaziulusoy and Brezet’s discussion is a general one about integrating theories to advance design for sustainability, although it might be read as a proposal on how to improve design for sustainability because of its focus on what companies can and should do.

Lähteenoja et al. (2023) integrate the fundamental insights from Young (2008) with Buchanan’s orders of design (Buchanan, 1998). The intention is to create a foundation to strengthen the application of the Transition Management framework to policy processes with a special focus on addressing “5–15-year mid-range dynamics” (Lähteenoja et al., 2023, p. 3). They deploy this to analyze the efforts in Finland to construct, in a participatory manner and across levels and areas of government, the 2030 Agenda Transition Arena. In their case, design in context objects are concrete tools, goals, visions, narratives, and pathways to realize the transitions ambitions devised at the systemic and policy levels. The process is not unidirectional, and thus, during the project there are phases where policy informs system and concrete design, and others where the directionality is reversed. There is also more communication, construction of things (things understood in general and not only as material objects), and strategic planning or systemic integration, which correspond to Buchanan’s four orders of design. Communication and construction of things tend to be related to design in context while strategic planning and systemic integration are related to design of context. This is a very sophisticated effort to create a framework that integrates and expands the role of design and designers in a Transition Management process. Lähteenoja et al. (2023) point out that “future research could bring in theoretical and methodological perspectives from, for example, systems science and science and technology studies, to further understand agencies of design action in context of transitions” (p. 19). This is what we are attempting to do by integrating Young’s levels of design with Akrich’s concepts of in-scription and de-scription. However, our effort is not restricted to analyzing the agency of designers in transitions only, but to generate reflexivity on the design agency of transition scholars.

2.3. Design in the environmental innovation and societal transitions journal

The literature mentioned above shows that the design research community has been discussing how to learn and contribute to sustainability transitions. In contrast, design is not an explicit topic in the EIST research agenda (Köhler et al., 2019) and there are few articles on design and transitions. In this section, we review articles that either explicitly or implicitly refer to design and/or mobility, and in the discussion section we reflect on how design can contribute to the sustainability transitions’ research agenda.

We identified these papers by searching the EIST journal for design and/or mobility and/or transportation and/or technological

design. On design or technological design, we found 30 articles, only one (Sovacool et al., 2019) addressing aspects of vehicle design and one on system design (Naidoo, 2020). All others were either research design, institutional design, or other aspects that do not address design in depth. We identified 28 articles on mobility or transport, but all of them focused on governance or regulation aspects of electrification of cars or bikes or scooters. Birtchnell et al. (2018) was part of this search and we consider that it addressed issues of design from the margins although without using the word design explicitly.

Three papers in EIST stand out for their use of design considerations in the context of sustainability transitions. We have plotted them in a cartesian field (Fig. 2) where the y-axis goes from incremental design to radical design, and the x-axis goes from insular (conducted by one organisation) to systemic (requiring the participation of several organizations).

Sovacool et al. (2019) set out to analyze the efforts of incumbents in the car industry to make innovations in electric vehicles by contrasting the strategies behind the BMW i3 and the Fiat 500. Their main argument is that BMW deployed a transformative change-shaping strategy, creating a whole new design and production process, which had the potential to alter the company's development path. They emphasize key concrete design features, such as using lightweight components and materials, designing battery packs in replaceable modules, and making the vehicle central in mobility services for selected cities. In contrast, Fiat reluctantly retrofitted its Fiat 500 to be electric just to comply with European regulations, evidencing what the authors dubbed as a conservative sustaining strategy.

This analysis activates implicitly a process of de-scription of central products to powerful incumbents, to demonstrate how transformative or conservative they are. However, the conceptual development of transformative vs conservative is limited in this case, because it restricts the analysis to a transition in automobility from combustion engine vehicles to electric vehicles, which is a technological component substitution strategy. In other words, the implicit design of context is accepted: electrification. They are not addressing the "big picture questions" (Köhler et al., 2019, p. 3). Nonetheless, its contribution lies in showing how incumbents are conservative even when they attempt transformative product design and manufacturing innovation (BMW i3) because of their position in designing, which supports the established idea that incumbents are reactive to change and incapable of delivering on systemic radical changes needed for sustainability.

A contrasting example of designing is offered by Birtchnell et al. (2018). They implicitly use design considerations in the analysis of mobility scooters in Australia, specifically their transformative potential in car dependent cities. This analytical strategy questions many of the taken-for-granted scripts of electric vehicles that do not challenge the core features of the dominant technology: they are oversized, overweight, overpowered, have considerable infrastructure requirements, are a danger to humans outside and inside the vehicle, and dis-serve those who most need them—people who walk with difficulty. By analyzing mobility from the point of view of electric scooter users, car-centered mobility appears strange and unfit for a sustainable mobility system.

Naidoo (2020) tackles the question of designing large systems, and considers how to transition to a sustainable financial market

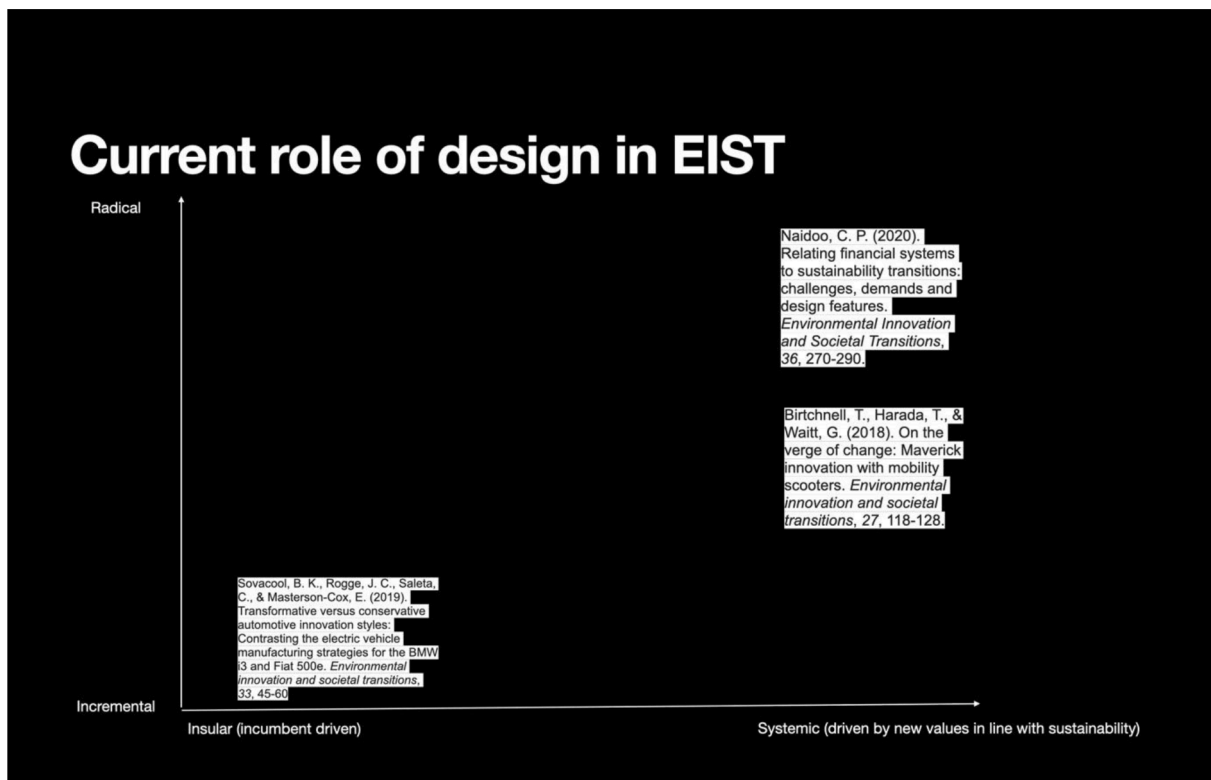


Fig. 2. three articles addressing design issues in EIST according to their radicality and their systemic quality.

system. The author first considers the characteristics of a transition that is subject to active holistic intervention design, which is different from technologically led structural transformations, and proposes five transitions' demands on financial systems—directional changes; temporally bound dynamics; co-existing systemic impacts, such as creating equality as a core element of the system; awareness and consideration (instead of abstraction) from the contested social context; and contextual experimentation to adapt to the changing conditions of a transition. The author proposes six “design features for financial systems response to sustainability” (p. 282), and does not consider the feasibility of such a design enterprise, but frames it as a design challenge, while considering its conditions and suggesting the actions to be taken. The author proposes implicitly that transition scholars should take the position of designing, and outlines an unprecedented systemic design effort that covers Young's three levels simultaneously.

Keller et al. (2022) consider how MLP [multi-level perspective] and social practice theory (SPT) complement each other, which becomes a concrete analytical proposal on connecting what Young (2008) terms the designing context and the design in context. MLP facilitates the analysis of the former and SPT the latter. This could create an opening for transition opportunities, both from above and below. We attempt to do something similar by observing structural stories as expressions of scenarios of designing context, and concrete design efforts as design in context, but we focus on how to connect them. Song et al. (2023) present an analysis of the policy and governance of electric vehicles in China which is restricted to Young's (2008) level of design of context without considering connections to the other levels. Krlev and Testriep (2022) propose a noteworthy discussion on how relevant contributions of innovations—social innovation and technological innovation—can be measured. The value of this contribution lies in the focus on measurement as an entry point to connect what Young defines as design in context with designing context. Although these three contributions touch upon the themes we consider in this article, they do it in a way that falls outside the conceptual scope we have defined.

To sum up, there is an emerging and vibrating literature on design and sustainability transitions especially among design researchers which takes place in design journals. In EIST there are a few articles that aim at contributing to transitions discussions by activating insights from developments in design knowledge. Our purpose is to contribute to this last effort by presenting a tentative framework for transition scholars to focus on aspects that open for design processes for sustainability transitions.

3. Methodology

To research the question, “What roles can design play in sustainable transitions in mobility?” we consider some of the developments and controversies on mobility in the Greater Copenhagen region during the last four years. Our analysis is based on three sets of data. The first data set consists of official documents, minutes of meetings, workshops and conferences related to an Interreg project called “A coherent transport system for Greater Copenhagen 2050” that was conducted between 2018 and 2021 (Greater Copenhagen, 2021). Data was collect by two of the authors of this paper who themselves participated in the project and acted as members of the project's steering committee. The involved authors took notes on project activities and the six meetings of the steering committee, the kick-off conference of 2018 and the closing conference and final report of 2021. The second data set consists of a documents from an activist group which was developed partly in relation the activities in the Interreg project. The final dataset consists of design work developed as part of an industrial PHD project conducted in collaboration between a university partner and an architectural company involved in mobility system design (Martin, 2021).

Across these data sets we analysed the moments in which concrete design proposals for sustainability transitions were considered and how they were treated by different actors involved. In this paper we highlight the instances that best exemplify how a sustainability transition discussion that normally focuses on broad governance and regulatory issues, momentarily focused on concrete designs and how different actors produced these and reacted to these.

In Young's (2008) words, discussing transitions should not only be about design of context (governance) and designing context (system), but also about design in context (component), and how these three levels are connected. We argue that this needs to be complemented with two other aspects. The first is to make visible how designs – and their critique of context - are influenced by the position of those who create them. The second is to make visible how policy actions aimed at changing the context depends to the how polices to realize the design are actively considered. In other words, critique and innovation are connected through all the levels of design.

Accordingly, for the following section, we will focus on making visible and analyzing the following aspects in selected examples of design and expected transitions:

- The position of design: Where do actors act from in their critiques/innovations?
- Critique/innovation: How does a critique of the existing, (de-descriptions) imply innovations (in-scriptions)? How do innovations embody, explicitly or implicitly, a critique of the existing?
- The levels of design and their connections: How are concrete products, objects and components connected to the system level and the policy level?

In the next section, we apply the framework outlined above to exemplify how to analyze design in transitions.

4. Analysis of design in mobility in GCPH

We present three design efforts made during the last few years to influence the development path of mobility in the Greater Copenhagen region. The first one is based on a document compiled by climate activists that uses knowledge, developed in the context

of the Interreg project, to try to influence politicians. The second one is based on a PhD thesis on Copenhagen with a design in transition perspective (Martin, 2021). And the third one is a direct product of the Interreg project, in the form of a hired report to the firm Incentive, which was not included in the closing report of the Interreg project.

4.1. The climate movement in North Zealand—design in context

A group of activists, Klimabevægelsen i Nordsjælland (The Climate Movement in North Zealand), published the report ‘Ja-vi har et valg (Yes, we have a choice)’ in November 2021 (Stavning and Schrøder, 2021). The aim of the document, and a subsequent online conference, was to raise awareness among politicians and voters about climate issues related to mobility in the wake of the upcoming municipal election. However, the document was not restricted to policy discussions on the benefits of cycling and the dangers of automobility, which belong to the level of design of context, but also included concrete proposals on road design to support a transition to sustainable mobility. The environmental activists welcomed a contribution from one of the authors of this article, explaining why combustion engine cars were incompatible with sustainability objectives, and why electrification would not solve its main pitfalls (Pineda, 2021). This was based on research by Valderrama and Elle (2020) which was produced in the context of the Interreg project. The environmental activists were also keen to cover the level of design in context, to expose the unsustainability of business-as-usual solutions and new designs, with a transition perspective.

The presented de-scription of cars can be summarized as follows. The main scripts of a car are its size and weight; engine technology; passenger and load capacity (the standard capacity for private vehicles is one driver and four passengers); and speed. In GCPH, the maximum speed limit is 130 km/h on highways, 80 km/h on country roads, and 50 km/h in cities. Cars are designed to race at speeds above 130 km/h. For historical reasons (Mom, 2013), the combustion engine (CE) became the standard, but it was a poor design for two reasons. First, the energy efficiency of the engine was extremely poor, converting at best 27 % of the chemical energy in the fuel to movement (including internal parts of the engine), which means that 73 % or more was lost as heat (Albatayneh et al., 2020). Second, optimal energy conversion occurred at speeds between 50 km/h and 80 km/h, which was outside the range of normal operation (Nasir et al., 2014). Therefore, cars operated mostly at inefficient conversion energy speeds, making energy inefficiency even worse. Electric cars have inherited the size, weight, and speed inefficiency from conventional cars, even if they can be better controlled and have zero emissions in operation.

The document included a presentation of the model 2 minus 1 vej (two minus 1 road) for rural roads (Bonnievie, 2021), which we consider an in-scription for the designing context level. The normal design of rural roads, according to existing standards, is a road that is wide enough to accommodate two vehicles, one in each direction. The standard design speed for rural roads in GCPH is 80 km/h and there is no obligatory requirement to allocate space for cyclists or pedestrians, even though they are regular users. In practice, such roads end up being too narrow to accommodate cyclists and pedestrians, and there are several deaths every year where cyclists or pedestrians are run over by drivers (Kaplan et al., 2014). As shown in Fig. 3 the 2–1 road is a designing context element that needs increased attention from all users, including drivers, cyclists, and pedestrians. In general, it also requires driving at lower speeds. The road is wide enough to accommodate two vehicles, but it is marked to reduce its capacity to only one lane, with space left on both sides for cyclists and pedestrians. When two vehicles are present, the drivers have to reduce speed and invade the marked sidewalk to allow the other vehicle to pass.



Fig. 3. Bonnievie (2021) p. 14.

The document also featured de-scriptions of the institutional lock-into automobility, the dependency on cars for everyday family life (Kattler, 2021, p. 10), the physical planning of residences and industries to facilitate car travel, the persistent protection of car makers interests (Kattler, 2021, p. 11) and the continuous investment on highway expansion and international connections, like the toll tunnel for cars stretching between Helsingør and Helsingborg (Kattler, 2021, p. 12). The latter is not only an example of infrastructure that favors car mobility, it also requires growth in car use to justify the investment. At the same time, this type of infrastructure is difficult to convert into active mobility infrastructure in the future, if needed. These de-scriptions belong to the level of designing context, but the editors of the document considered that they became stronger when supported by informed critiques of designs in context (the car).

The document also noted the benefits of cycle superhighways for CO2 reduction (Hartmann, 2021), the synergies between regional tourism and cycling (Bonnievie, 2021; Larsen, 2021), and the positive impact of cycling on health (Tophøj, 2021). All this is aimed at influencing the design of context to frame more positive governance and institutional development for the use of active mobility modes of transport, like conventional cycling. In other words, these efforts aim to reconfigure the context to provide more space for the specific design of bicycles, and less for cars.

In short, the case of The Climate Movement for North Zealand illustrates the growing awareness among activists committed to a sustainable transition, to articulate a critique of the existing situation, and a way forward by connecting developments at the levels of design of context (policy) with design in context (concrete product designs, in this case vehicles) and designing context (roads, infrastructure). The position of designing is that of activists who promote a sustainable transition, and whose arguments become more compelling and articulated when anchored in a structured design framework, like the one we present here.

4.2. Redesigning Copenhagen for urban active mobility—designing context

The second effort is based on a PhD dissertation by Martin (2021). This dissertation consolidates a vision for Copenhagen to become a sustainable and livable city by implementing and integrating existing in-scriptions like cycling boulevards, green areas, super-blocks, and traffic islands. The proposed vision is for reshaping Copenhagen from a car-centered city to an active mobility city with public transport, while restricting the use of private vehicles as much as possible. In other words, as an urban design exercise, this becomes a unique effort to completely redesign the designing context of mobility for a city like Copenhagen.



Fig. 4. Existing and possible views of a street in Copenhagen from Martin (2021).

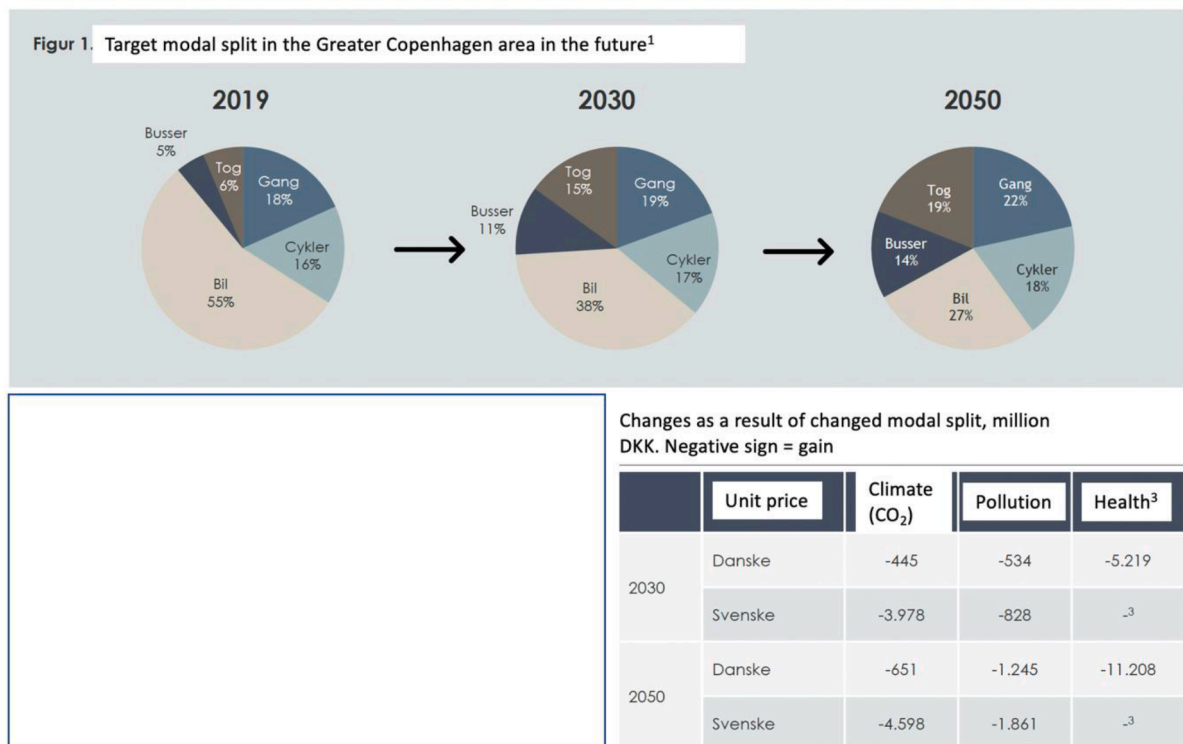
Martin (2021) has created an integrated and detailed view of Copenhagen that presents all the gains in sustainability, and what the city would look like from the air and from the streets. It is also an analysis of what it is missing because of its current configuration. Compared to this desired view, the current conditions are revealed as scarce, confined, and dangerous. In this sense, Martin simultaneously activates a de-scription of the current conditions and an in-scription of the desired ones. As shown in Fig. 4 a normal avenue in the city is currently in-scribed and optimized for car traffic (pictures at the top). The pictures below show Martin’s vision of the future of Copenhagen in-scribed to prioritize urban and public spaces, public transport and active mobility. Martin’s detailed exercise is in stark contrast to existing visions of the future in which technology is the driving element (Martin, 2021, p. 142–147; Ehlers, 2018; Möller et al., 2019; Simpson et al., 2019). In these technocentric visions, autonomous electric vehicles define the future of mobility, and the whole city is reconfigured around this. In other words, Martin’s work places the effort on configuring the designing context, while an autonomous car-driven vision of the future emphasizes the design in context as the main transitioning element that defines the rest.

Martin’s position of design is not only academic. He conducted this critique/proposal design exercise as an industrial PhD in Denmark in collaboration with Ja-Ja Architects, that is committed to producing urban designs that support a transition to sustainability. Martin and Ja-Ja Architects produced a visual critique of the existing designing context, touching upon aspects of the other two levels, and an integrated proposal of how to change it considering the whole of Copenhagen City. This detailed vision based on urban sustainable principles stands in contrast to the variety of future visions of mobility which are based on the advent of autonomous electric vehicles and are produced by car makers or consultancy firms working for incumbents.

4.3. Behavior and transport economics—design of context

One of the major results of the Interreg project was the production of a desired transition on the modal split of GCPH, and an estimate of its benefits. This was a modelling exercise to estimate what a less unsustainable modal split for the region would look like, and what would be its economic consequences. Trivector (2020) conducted the forecasting of the evolution of the modal split shown in Fig. 5. The consultancy firm Incentive (2020) shows that the biggest gains were in health, which however, can only be calculated in

If the modal split changes as indicated in Greater Copenhagen, it will overall benefit both climate, air pollution and health in 2030 and 2050



¹ Note: Trivector (2019) har opgjort turtfordelingen på baggrund af TU (Danmark) og Resvaneundersøgning (Skåne). ² Sundhed inkluderer både cykel og gang. Gang er pr. km. værdisat til det dobbelte af cykling, jf. side 18. ³ I de svenske enhedspriser (ASEK) er der ikke opgjort en sundhedsgavn pr. km. I stedet opgøres andelen, der cykler regelmæssigt og en reduceret relativ risiko for at dø, jf. Trafikverket (2018b).

Fig. 5. Economic analysis of a sustainable modal split for GCPH. Incentive (2020) p. 24 Partial translation by the authors. In the pie chart, busser is bus; tog is train; gang is walking; cykler is biking; and bil is car.

Denmark which has included health in the unit costs that the Finance Ministry and the Transport Ministry use to officially assess investment projects. Gains in pollution reduction and emissions reduction vary in Denmark and Sweden, indicating there is room for improvement if the international alignment of unit costs across borders in Europe, is worked on.

We consider this an effort to directly influence the design of context level by creating new knowledge that reveals the potential benefits of reducing car travel and improving active modes of transport. This builds on previous efforts in Denmark to make visible the health benefits of existing infrastructure interventions, based on current valuation instruments. In 2018, the Cycle Superhighways initiative commissioned a cost benefit analysis of the planned extension of paths for the Capital Region. The initial analysis by [Incentive \(2018b\)](#) showed the rate of return as 11 %. More recent calculations have found it to be as high as 23 % ([Rich et al., 2021](#)).

These efforts carried out by the Cycle Superhighway initiative, experts in the Capital Region and researchers of the Interreg project, reveal their position on design and their commitment to integrate health considerations in the planning and operation of transport. It is worth mentioning that regions in Denmark, including the Capital Region, do not have planning or executive responsibility on mobility. Their main responsibility is the administration and coordination of health institutions. However, they do have a developed interest and a facilitating capacity in terms of connecting health to other areas of society, like mobility. Therefore, de-scribing the dominant transport system metric using its own modeling instruments, was an unusual task. The main insight here is that designers, engineers, and transition scholars contribute consciously or unconsciously to the development of specific large technological systems when they accept, without questioning, established implicit or explicit leading values and metrics. In the case of cars and public transportation, the current established dominant value is the minimization of the duration of transport, and the leading metric is time minimization ([Holden et al., 2019](#); [Incentive, 2018a](#); [Whitelegg, 2020](#)). This is what is constantly measured by the state through its own bodies of regulation, operation, and monitoring of the transportation system, and the context of design. If, as suggested by the new cost benefit analysis, the focus was shifted from saving time to optimizing public health gains, the same models that today lock-in the development on transport into an unsustainable trajectory, could be used to create a transition path to sustainability.

5. Discussion: the potential of design

In the previous section, we described three selected efforts to activate design to influence the development of Copenhagen and Greater Copenhagen in a sustainable transition direction. We made explicit the position of design from where these efforts were made. We illustrated the way they entail connections across levels of design and how innovations and changes (proposed in-scriptions) imply a critique of the existing (de-scriptions). In this section, we will discuss the consequences of our analysis for the sustainable transitions research agenda, and how we relate our framework to MLP.

5.1. Design and the sustainable transitions research agenda

Based on our analysis, we present the roles design can play in the research agenda of the sustainability transitions community as outlined by [Köhler et al. \(2019\)](#).

In understanding transitions, there are two emerging research directions: first, the “destabilization, decline, and phase-out of existing systems and regimes” ([Köhler et al., 2019](#), p. 6) requires critical design analysis of key components and technologies. We have shown in our analysis how the de-scription of conventional car designs and electrical vehicles becomes necessary and productive in this regard. The same applies to car-oriented infrastructure and urban design that accommodates cars as a prioritized function, as illustrated in the examples in [Section 4](#). We claim that design offers sustainable transition scholars, the tools to improve this critical stance towards existing unsustainable systems covering product, system and governance context, and their interconnections.

Second, design can also contribute to imagining and experimenting with “interactions between multiple emerging and existing technologies” ([Köhler et al., 2019](#), p. 6). Design has always been about interactions and encounters, and not about producing single products or technologies ([Binder et al., 2011](#); [Manzini, 2015](#); [Martin, 2021](#)). We have suggested that taking active roads and streets, bicycles and health gains as the main elements and exploring how they complement each other, has a higher potential to design alternative sustainable mobility systems, than following the current paths of development. This is in line with the findings of [Gaziulusoy and Ryan \(2017\)](#) who showed how designers’ main contribution to creating a sustainable future lies in their capacity to exercise and support inquiry in strategic, tactical, and operational activities, which would address all levels of design. We support their suggestion for designers, and extend it to researchers in sustainable transitions.

Regarding civil society, culture and social movements in transitions, there are implicit references to participatory design and co-design in relation to the “direct effects of CSOs [civil social organizations] on industrial innovation, by providing protective spaces for grassroots innovation, and by creating consumer demand” ([Köhler et al., 2019](#), p. 10). Design also has the potential to contribute to understanding change “by challenging taken-for-granted systems of meaning” ([Köhler et al., 2019](#), p. 10), experimenting with new meanings, and contributing to their upscaling and diffusion. We have illustrated the role that design can play in transformations, such as those coming from climate activists, or the role of health as a significant metric in mobility. It is not just a discussion among experts but an interactive planning and designing development that requires intervention and knowledge creation. According to [Ceschin \(2014\)](#) and [Ceschin and Gaziulusoy \(2016\)](#), these could become design activities and roles in a sustainability transitions effort, to be assumed by designers. To complement this, we propose that such an endeavor would not only be a process of applying sustainable transition insights to design, but also a contribution to sustainable transitions scholarship.

For businesses and industries in sustainability transitions, there is an implicit reference to design as: “firms and other industry actors...as innovators, they develop new products, services and business models, contribute to market creation for novel technologies, or work toward the formation of industries” ([Köhler et al., 2019](#), p. 11). However, they acknowledge that “transition scholars have only

just started to look into the role of business and industries” (Köhler et al., 2019, p. 11) and by extension the knowledge base and design practices. They also “find newcomers driving radical innovation while incumbent actors obstruct major technological and institutional changes” (Köhler et al., 2019, p. 12). What we propose here is that it is not possible to only focus on innovation as a process of adding positive change to the existing regime. Design for sustainable transitions requires a strong critique of the existing scenario, which incumbents and newcomers find challenging because of their difficulty in engaging in radical change. They tend to invest their efforts in influencing the designing context and the design of context to preserve their core components, such as cars. The examples in Section 4 show how the opposite movement is more challenging but becomes natural for organizations committed to sustainability.

Therefore, opportunities for change are not to be found in research laboratories alone, but in extensive regional experimentation as well. This also has value for transitions and everyday life where there is an implicit reference to design. In transition studies, there has been a shift from seeing customers and citizens as passive actors accepting (or rejecting) the developments of others, to viewing them as co-creators of sociotechnical change. This can be further strengthened with the framework we present in this article.

5.2. Design and MLP

Birtchnell et al. (2018) propose that MLP should be expanded to cover five levels of structuration. The landscape is the same level of exogenous influences. But the regime should be extended to cover the dominant system, which in our case is the car system, and subaltern regimes. These are systems that exist although they experience numerous disadvantages because they are measured against the norms of the dominant system. Then there is the niche level composed of alternative systems that are sustainable from the core, but are also smaller, weaker and at a disadvantage in front of the selection environment (the regime). And a fifth level, they propose, is that of Mavericks that cover users who are excluded from all the other levels. However, they don’t passively bear their exclusion. Instead, they make efforts not only to achieve recognition but also to transition. In other words, they propose a transformation for the whole system (see Fig. 6).

Inspired by this, we propose the following conclusion to outline the roles that design can play in transitions analyzes. As proposed in Section 4, we should engage in interrupting by de-scribing those aspects of the current regime that embody unsustainability: in our case the pre-eminence of time minimization as the leading metric for all transport forms; the unquestioned focus on highway expansion; the common practice of adapting urban environments to facilitate car travel; and the very essence of normal car design.

We also explain how we should engage in supporting those aspects coming from subaltern regimes (in the case of the GCPH public transport) and niches (bicycle system) that potentially can become part of a sustainable transition. For instance, we suggest that health

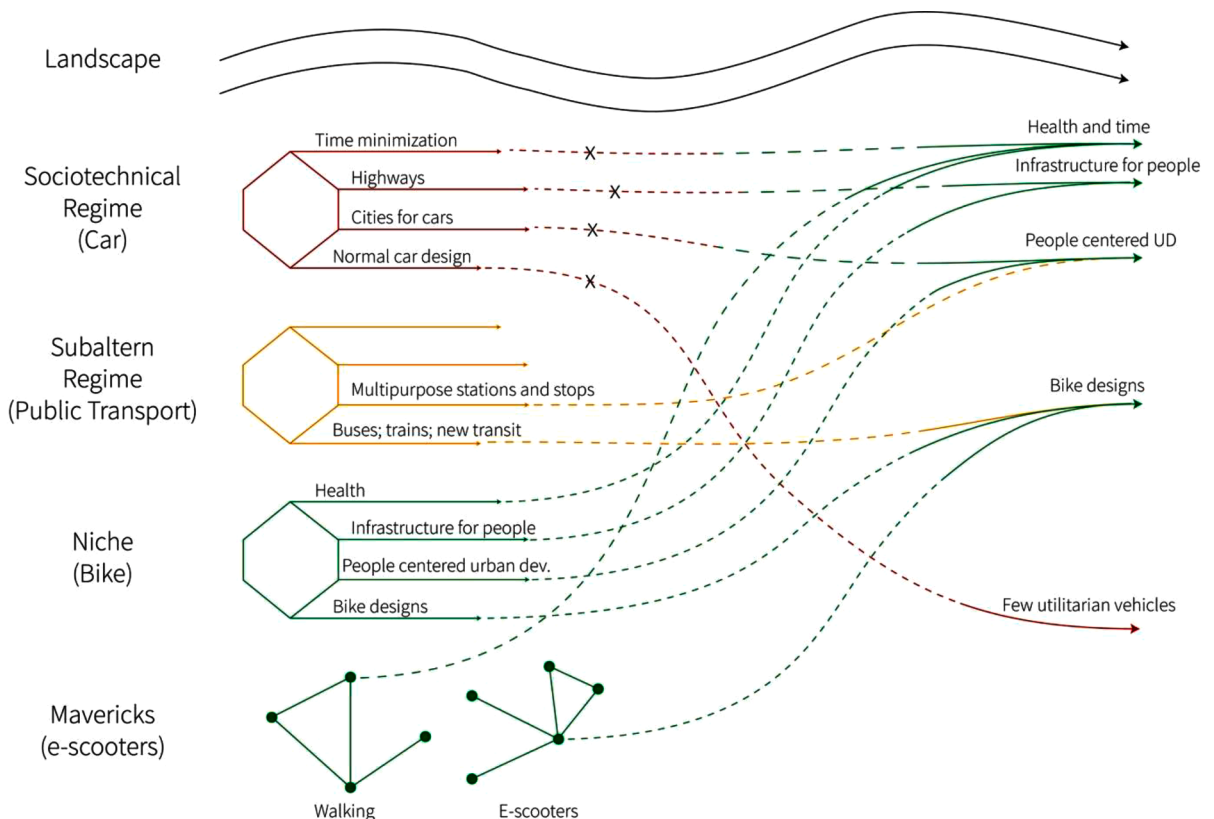


Fig. 6. An expanded MLP.

optimization could become a significant metric, with at least the same importance as time minimization. We also suggest that infrastructure should be developed to support cycling and active modes of transport in line with [Martin \(2021\)](#). Although we did not cover discussions about walking as a mode of transport, we suggest that it could be one of the Maverick developments to support such a transition. Vehicle design, as understood today, should be completely interrupted and redirected. We did not cover the role of electric scooter users in Denmark and Sweden, but building on what [Birtchnell et al. \(2018\)](#) have suggested, we propose that future research could gain from their activities to support the design of new types of vehicles, and their inclusion in appropriate urban design and infrastructure. In other words, future vehicle designs should become lighter, smaller and more inclusive.

6. Conclusion

We set out to address the following research question: What roles can design play in transitions to sustainability? We researched this question through the example of mobility in the Greater Copenhagen region. Based on the evidence presented, we conclude that design can have a pivotal role in destabilizing existing regimes and creating systemic alternatives.

Our argument is that sustainability transitions scholarship should incorporate discussions on design. To support this, we propose attention to three aspects. The first is the position of design. Where do the actors that propose critiques of existing systems, or support systemic innovation, act from. There is a significant difference between initiatives that come from incumbents like car makers ([Sovacool et al., 2019](#)), and relevant actors that struggle to support radical transformations like city or regional administrations, or actors that act from the margins or outside the existing systems, like Mavericks ([Birtchnell et al., 2018](#)).

The second aspect is that the three levels of design ([Young, 2008](#)) are intrinsically connected. Therefore, actions at the level of design of context must be connected to initiatives in the designing context and the design in context. Otherwise, initiatives at the policy level will never be reflected in the key components that support a sustainable transition. Conversely, failing to address what is packed into the design of products or technologies, like electric vehicles, necessarily means accepting a proposed structure for the designing context, and the design of context. If these connections are not revealed and analyzed, scholarship in sustainable transitions might end up supporting system transformations that will further worsen our ability to address the grand challenges ([Köhler et al., 2019](#)).

The third aspect to consider is that all innovations are connected to critiques of the status quo. Unfortunately, these two are sometimes separated, hence, the calls for greater attention on breaking down and dismantling unsustainable regimes ([Henbick et al., 2022](#); [Johansen et al., 2018](#)), or studying the demise of large technological systems ([Sovacool et al., 2018](#)). However, a stronger analysis of how de-scriptions and in-scriptions of key components and infrastructure are intrinsically related would strengthen the capacity of the sustainability transitions community to advance the sustainability agenda. The strength of de-description strategies is that they show how context and system level principles are reflected in the design features of key components; and how observable phenomena at the level of system and context, like structural stories ([Freudendal-Pedersen, 2020](#)) and state driven argumentation for investments, are connected to features in key products and components.

In line with [Sovacool et al. \(2019\)](#) and the STRN [Sustainability Transitions Research Network] research agenda ([Köhler et al., 2019](#)), design approaches can help assess the transformative potential of technological innovations, to increase the capacity of the sustainable transitions community to criticize the existing unsustainable sociotechnical systems and their business-as-usual approaches. There are already many articulated criticisms to the automobile system ([Bohm et al., 2006](#); [Conley, 2016](#); [Dennis and Urry, 2009](#); [Urry, 2004](#)), but more can be done to assess the technological lock-in of key component design (car), infrastructure, the built environment, and normalized behavioral approaches, as we have outlined. In other words, the strong literature on the critique of unsustainable systems focusing on the design of context and designing context, could be complemented by explicit efforts to de-scribe designs in context.

CRedit authorship contribution statement

Andrés Felipe Valderrama Pineda: . **Morten Elle:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. **Jens Iuel-Jensen:** .

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

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Data availability

Data will be made available on request.

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