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Rebound Archetypes: A Card-based Tool to Help Designers Think Through the Rebound Effects when Designing for Sustainability

Laetitia Bornes*, Marcia Tavares Smith*, Oliver Bates, Gordon Blair, Catherine Letondal, and Rob Vingerhoeds

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In this paper, we present our work in developing a tool to help designers and decision-makers in considering rebound effects within their design or decision process. The concept of rebound effect is defined in multiple ways. In this paper, it is used to refer to any unintended consequence resulting from an intervention that goes against the initial intention or has social or environmental impacts that are perceived as negative. It is challenging for designers to consider rebound effects during the design process, let alone to engage stakeholders in evaluating the potential risks associated with these effects. The Rebound Archetypes tool, presented in the form of cards, has been designed to support designers in facilitating workshops on rebound effects with “well-intentioned” stakeholders, such as mission-oriented companies, NGOs and public sector representatives. The objective is to enable participants to engage in a process of collective decision-making regarding the potential rebound effects that could result from an intervention. This could be the introduction of a new product, service, technology, or strategic decision, policy. The tool also allows participants to understand the associated risks and to collectively decide on actions to take, such as (a) cancelling the intervention or redefining it, (b) attempting to mitigate potential rebound effects, or (c) accepting the risk and monitoring it. The cards are designed to facilitate these activities without inducing paralysis, and can be used in various ways to adapt to the design process and the participants' level of expertise. Primarily, they were created to embody reflection steps around rebound effects, but they aim to become less necessary as the ‘players’ gain autonomy. This paper discusses the process of

creating the Rebound Archetypes cards and the insights we have gathered on the challenge of considering rebound effects in design.

KEYWORDS: rebound effect, design cards, sustainability, workshop, decision-making

RSD TOPIC(S): Methods & Methodology

Introduction

The challenge of addressing climate change and the impact of human activity on the environment is arguably one of the most pressing and critical issues of our time. Digital technologies is an area that requires attention, as the carbon footprint of Information and Communications Technologies (ICT) is estimated to be between 2.1-3.9% of global greenhouse gases emissions (Freitag et al., 2021). The attempts to address this situation have thus far been insufficient. For years, efforts to tackle carbon emissions have been focused on reducing energy and resources in products and services. Nevertheless, strategies to increase efficiency have not yielded the desired results in terms of reducing environmental impacts (Park, 2004; Blair, 2020). One significant reason for this failure is the phenomenon of rebound effects.

The linear and reductive approaches to sustainability that have been employed thus far (e.g. eco-design, eco-efficiency and eco-feedback) do not permit the accounting for the complexity of sustainability and the interactions within socio-technical systems, such as rebound mechanisms (see Related work, Figure 1). For instance, the utilisation of carbon calculators that focus on isolated devices or activities (Smith et al., 2024) fails to capture the systemic aspect of ICT emissions, as this sector serves as an infrastructure or an enabler of production in other sectors (Williams, 2011). It is therefore important to consider rebound effects and explore their systemic nature in order to effectively deal with the environmental impacts of digital technologies and beyond (Coroamă & Mattern, 2019; Widdicks et al., 2023; Guzzo et al., 2024).

Guzzo (2024) has urged the scientific community to develop tools to assist in the identification of rebound effects in ex-ante investigations (i.e., before they occur). The objective of this research, presented in this paper, is to respond to the aforementioned call by developing a card-based tool. The focus of the research described in this paper is on rebound effects from the perspective of the authors' research background, which

encompasses design research and digital innovations. The Rebound Archetypes tool is the result of a joint collaboration of research groups in France^[1] and the UK^[2].

This paper first explores the related work on rebound effects, card-based design methods and tools for dealing with rebound effects. Next, the methodology used in this project is explained, followed by insights from the initial interviews. Then, the Rebound Archetypes tool is described and the main findings from the research are summarised. The last section discusses what has been learned through the design and the development of the cards about rebound effects, how designers deal with them and how rebound effects can be tackled at the design stage of innovations.

Related work

This section aims to clarify the concepts of rebound and indirect effects, establish the need for a systemic approach to address them, justify the format of the tool, and situate our work in relation to a similar existing tool.

Rebound effects and indirect effects

The impacts of a product or service are typically described as resulting from two types of effects: *direct effects*, which include the environmental footprint related to resource extraction, manufacturing, transportation, use, and end-of-life disposal, as well as associated equipment; and *indirect effects*, meaning the effects produced by the changes in usage and practices this product or service causes. The term *rebound effect* is used to describe a mechanism that causes an increase in demand and/or production, thereby counteracting an initial intention (Coroamă & Mattern, 2019). When cost reductions, time savings, or other benefits associated with a product increase the usage of that same product, or enable the use of other products or services that consume energy or resources, this is referred to as a *rebound effect*. For instance, enhancing the efficiency of car engines enables drivers to save money, affording them the opportunity to drive more or to allocate their funds elsewhere, such as travelling by plane.

However, the definition of a rebound effect is somewhat restrictive, due to its original definition, and vague, due to the evolution of its scope. Indeed, identifying a counteracting effect requires ascertaining an initial intention, which can be challenging.

^{1]} <https://lii.enac.fr/>

^{2]} www.paris-de.org

Moreover, the concept of a *rebound effect* has been expanded to encompass not only an effect that directly counters an initial intention, but also systemic mechanisms that have other impacts. A *systemic rebound* occurs when changes in individual behaviours become visible at the scale of the sociotechnical or socioeconomic system, altering practices, lifestyles, and patterns of consumption and production (Bremer et al., 2023).

Finally, another potential risk of ambiguity associated with the term *rebound effect* is that it can lead to confusion about the nature of the phenomenon under consideration. Indeed, the term can be employed to designate a causal mechanism that is activated by a trigger, as well as the resulting effect, which may have an environmental and/or social impact. As illustrated in Figure 1, the savings made by drivers (*trigger*) will, through a rebound mechanism, be spent elsewhere, with the resulting effect of an increase in driving (*direct rebound effect*) or an increase in other activities, purchases, etc. (*indirect rebound effect*). The objective of this research is not to define or categorise rebound effects more precisely, but to mitigate indirect negative impacts within a design process. Consequently, the specific terminology will not be addressed, and we employ the term *rebound effect* in the broadest sense to encompass all the "non-obvious" and potentially adverse effects that may be of interest to designers and stakeholders (i.e. all indirect effects that have environmental or social impacts perceived as negative). Similarly, the concept of *drivers* (Guzzo, 2024), which are factors that are external to the intervention, has been excluded from the scope of this tool, in order to prevent it from becoming overly technical.

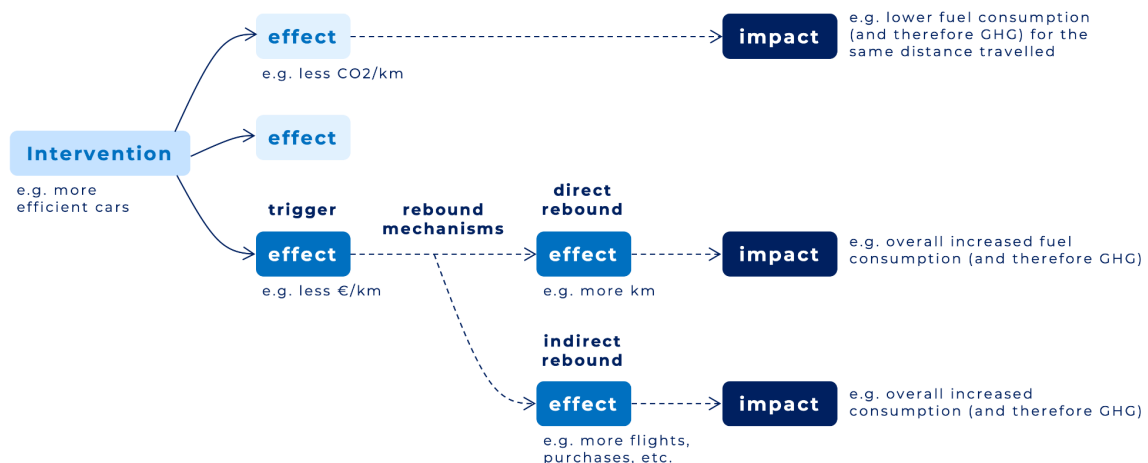


Figure 1. Trigger effect, rebound mechanism, rebound effect, and social/environmental impact.

A systemic approach to address rebound effects

The Sustainable branch of the Human Computer Interaction (SHCI) field has long been advocating for a systemic approach to sustainability (Silberman, 2014; Taylor, 2015; Knowles, Bates, & Håkansson, 2018). However, this has resulted in few concrete methods and tools to deal with the urgency of the situation (Bremer, Knowles, & Friday, 2022). In particular, the phenomena of rebound and indirect effects are a concrete manifestation of the systemic nature of sustainability, insofar as they result from interactions within a socio-technical system at several scales and temporalities. The nature of these effects renders any techno-solutionist approach ineffective. Some researchers therefore argue in favour of a concrete systemic approach to rebound effects (Bornes et al., 2022), and propose in particular to draw inspiration from system dynamics (Bremer et al., 2023; Widdicks et al., 2023). A systemic modelling methodology (Bornes et al., 2023; Bornes et al., 2024) has been developed to collectively represent and understand the orders of magnitude of existing (ex-post) rebound effects, and to develop and compare design mitigation strategies. The tool this article discusses is designed to anticipate potential rebound effects and reduce their risk (ex-ante). Future research could investigate the potential for a complementary use of the systemic modelling methodology and the card-based tool. For instance, the cards could assist in identifying existing rebound effects and anticipating potential future rebound effects following the implementation of a design strategy.

Card-based tools for collaborative ideation

Our objective is to provide designers with a tool to facilitate workshops on rebound effects, enabling stakeholders to engage in a collaborative decision-making process regarding the potential rebound effects that could result from an intervention. Design cards have been employed by designers to render the design process more visible and less abstract, as well as to facilitate communication between design team members and users (Wölfel & Merritt, 2013). According to Lucero, Dalsgaard, Halskov, & Buur (2016), design cards are effective because they serve as containers for tangible ideas, trigger combinatorial creativity, and foster collaboration, as they can be used as shared objects for discussion between participants.

Wölfel & Merritt (2013) defined five dimensions to characterise card-based tools: Intended Purpose & Scope, Duration of use and placement in design process, System or Methodology of use, Customization, and Formal Qualities. Given the initial objectives and the context of use of this tool, it was relatively straightforward to position it on the

first three dimensions. In terms of intended purpose & scope, our tool is context-specific and agenda-driven. With regard to the duration of use and the positioning in the design process, the tool is intended for use at a specific point in the design process, namely a workshop. With regard to the system or methodology of use, the intention was to provide users with suggestions for use without imposing any particular approach.

Among the seven content-based approaches that tools adopt to support ideation, identified by Peters, Loke and Ahmadpour (2021), we anticipated positioning our work on several categories: (A) Methods (collections of design methods or creativity strategies), (B) Prompts (provocative questions, triggers or abstract visuals), (C) Components (represent different components within a system to keep these salient during collaboration), and (D) Concepts (chunks of expert knowledge in a manageable manipulable form). According to Peters et al. (2021), the main problem with analogue (non-digital) tools, such as card-based tools is that "*the landscape of design tools is disproportionately characterised by a combination of: (a) research on tools that are not made available, and (b) available tools for which there is no research.*" They call for future work to strive to combine the two, i.e. to create tools that are both usable and the object of research, "*towards evidence-based practice*" (Peters et al., 2021). Through our research, we want to explore the understanding of the rebound effect, but also produce a set of cards that will actually be used by designers.

Circular rebound tool

In the literature review, we found a card-based tool that aims to help designers and decision-makers anticipate and mitigate rebound effects during the design process. This tool, called The Circular Rebound Tool (Das et al., 2023), proposes four steps: 1) identifying a challenge, 2) selecting a strategy from a set of proposed circular economy strategies, 3) mapping the selected strategy to the product life cycle, and 4) planning the next steps. The proposed strategies are presented in the form of cards, with one card for each type of circular economy strategy (e.g., reduce, repair, reuse, etc.). Each card provides detailed information on the strategy, the requirements for achieving it, potential associated rebound effects, and possible techniques for preventing these rebound effects.

The tool appears to be relatively straightforward to use, yet it is limited to circular economy design. Given that the only rebound effects presented are those resulting from a circular economy strategy, and that the only prevention techniques presented

are also linked to these strategies, the tool is not adaptable to applications other than the circular economy, such as the digital sector. Furthermore, it does not enable an understanding of the causal chains that lead to rebound effects, their possible impacts, or the combination of prevention techniques. We argue that a more generic and flexible tool is necessary, applicable to digital technologies, which would empower stakeholders to understand the underlying dynamics of rebound effects, identify new rebound effects in new situations, regardless of their interventions, and develop their own mitigation strategies.

Methodology

The objective of this study is not only to develop a tool to help designers and decision-makers think through rebound effects, but also to investigate, through this process, designers' current comprehension and practices regarding rebound effects, their difficulties in considering them, their needs, their thoughts, etc. Therefore, we approached our research from a *research through design* perspective (Frayling, 1994). We engaged in the design of the cards as a way to learn through the making as in a *designerly way of knowing* (Cross, 1982), testing and building upon what we learned in an iterative design process. The following research questions have been formulated:

RQ1: What are the current practices of designers with regard to rebound effects?

RQ1.1: How do (or why don't) designers consider rebound effects in their design processes?

RQ1.2: How do (or why don't) designers deal with rebound effects in their practices?

RQ2: How could a card-based tool help designers think through rebound effects within their design processes?

RQ2.1: How could a card-based tool help stakeholders increase their understanding about rebound effects, identify/anticipate potential rebound effects, tackle rebound effects through mitigation strategies?

RQ3: What can we learn from observing stakeholders considering rebound effects through the use of the cards?

To explore these research questions, we followed the methodology described below and illustrated in Figure 2:

1. **Literature review:** We conducted a review of relevant literature to situate our work in relation to other existing tools (e.g. Circular Rebound Tool, taxonomies

about rebound effects) and to gain a comprehensive understanding of the diverse forms and functions that design cards can take.

2. **Expert interviews and analysis:** We conducted semi-structured interviews with sustainable design and systemic design experts to gather insights about their understanding and practices regarding rebound effects. The collected data was then transcribed and analysed to gather designers thoughts, practices and needs, and to inform the initial design phase.
3. **Design V1:** The first version of the design was developed by integrating insights from the literature review and expert interviews. This phase ensured that the foundational design was both theoretically sound and practically relevant. The primary objective of the cards is to facilitate a workshop on rebound effects. Although the aim is for the cards to be modular, a standard workshop structure was required. Therefore, the design of both the set of cards and the workshop process was conducted in parallel, with the understanding that the former would be modified to align with the latter.
4. **Design walkthrough:** The preliminary design phases underwent walkthrough processes involving consultation with colleagues who are experts in participatory methods, as well as card and game design. This iterative feedback helped us refine the cards, as well as the workshop process.
5. **Design V1+:** Based on expert advice from the walkthrough phase, minor iterative improvements were made to enhance the initial design.
6. **Pilot workshop and interviews:** A pilot workshop was conducted in-person to test the initial prototype, followed by interviews to collect feedback from two participants. This phase aimed to evaluate the design in a real-world setting.
7. **Online workshops:** Additional workshops were conducted online to gather a broader range of feedback, evaluate the usability and usefulness of both the cards and the workshop process, and to test the design's adaptability to different contexts and settings.
8. **Design V1++:** Small, iterative changes were made after the pilot workshop and between workshops to implement 'quick wins' and address immediate feedback, ensuring continuous improvement of the design.
9. **Analysis of online workshops and pilot workshop interviews:** A comprehensive analysis of the data collected from both the pilot workshop interviews and the online workshops was conducted in order to identify strengths, areas for further refinement, and reflective findings.

A consolidated design, referred to as Design V2, is forthcoming and will integrate the insights and feedback from the online workshops.

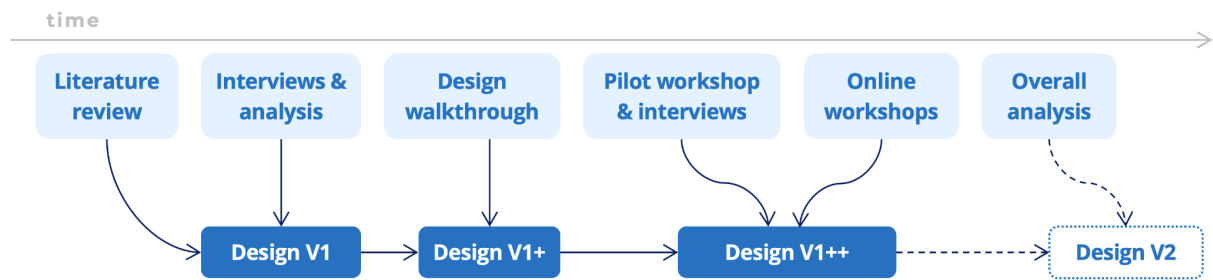


Figure 2. Methodology of the study.

Given that few practitioners address rebound effects in their practice, it was deemed more appropriate to adopt a participatory iterative design approach rather than a co-design approach. Furthermore, the methodology employed to develop this initial version of the cards and draw these first findings took account of the substantial time constraints. In fact, just over a month elapsed between the first expert interview and the last online workshop. The time constraints can be attributed to the agendas of the research projects involved and the time required to obtain ethical approvals. Prior to each interview or workshop, participants were provided with comprehensive information regarding the process, context, and intended use of the data, and were required to sign an informed consent form.

Experts interviews

The two first authors conducted online semi-structured interviews with four experts, as detailed in Table 1. Given the exploratory nature of the study, we did not attempt to recruit a representative sample of designers. Instead, we sought out designers who could contribute unique insights based on their complementary expertise, experience, or interest in rebound effects, systemic design, and sustainability. The semi-structured format (see appendices for the list of questions) allowed for both consistency across interviews and the flexibility to explore specific insights offered by each participant. The interviews were recorded, transcribed, and subsequently analysed to identify themes that will inform the design of the tool (see Main insights from the interviews).

Experts	country	researcher/practitioner	domain
E1	UK	mostly practitioner	sustainable design (product)
E2	Canada	mostly researcher	systemic/sustainable design
E3	France	practitioner	sustainable design (digital)
E4	Germany	researcher	circular economy

Table 1. Experts interviewed.

Iterative design

Our iterative process started with design sessions where we used flip charts paper and white boards to capture the main ideas and concepts we wanted to integrate into the cards (see Figure 3). These concepts were then translated into cards developed on a Miro board. The initial cards were printed out and evaluated during a walkthrough session prior to their utilisation in the pilot workshop. The observations made during the workshop led to the implementation of minor adjustments to the content of the cards and the development of the Miro Board space (where interaction with the cards would occur) based on the physical setting of the in-person pilot workshop. Subsequently, we hosted three online workshops, and made adjustments to the interactive space and workshop process between the online workshops. The feedback from participants and the analysis of the workshops are now being incorporated into the development of a new version of the cards (Design V2), which is still in development.

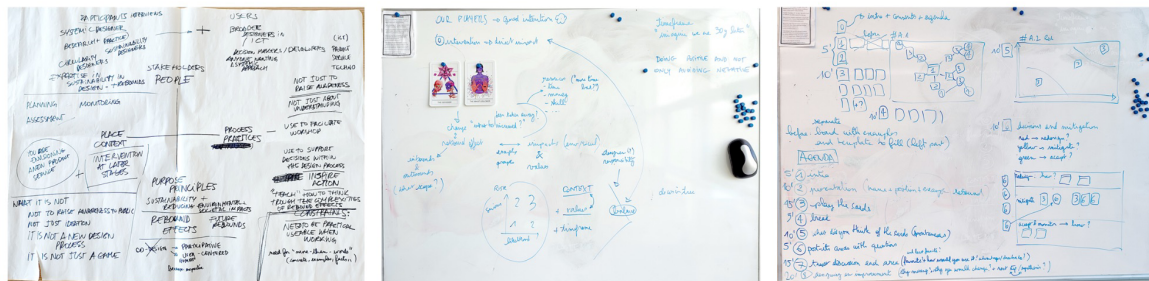


Figure 3. Sketches of ideation throughout the iterative process.

Pilot workshop (testing prototype) & interviews

The two first authors facilitated a one-hour session (workshop) in person with a group of six participants who worked in the same organisation and were part of a team in a short-term project. We printed out a set of cards and used sticky notes and flip chart paper to take notes and expand the use of the cards. For instance, the stakeholder cards (step 2) are yellow and suggest categories of stakeholders. We used sticky notes of that colour to annotate groups within that category relevant to the intervention being tackled. The session was not recorded, but notes on the use of the cards were taken during the session, as well as photographs of the cards, sticky notes and flip charts used (see Figure 4). Semi-structured feedback interviews were conducted with two participants (see Table 2) around five weeks after the testing session occurred. The interviews, which lasted approximately 30 minutes, were recorded, transcribed, and the main points were summarised.



Figure 4. Cards being used with flipchart paper and sticky notes during the pilot workshop.

Participant	country	role	domain
T1	UK	User Experience Designer	environmental science
T2	UK	Systems Architect	environmental science

Table 2. Testing participants interviewed.

Online workshops

The two first authors of the study conducted three online workshops with a total of 13 participants, as detailed in Table 3. Each 2-hour workshop was facilitated using Miro boards (see Figure 5 and Figure 6) and followed a structured set of activities described in Table 4.

Workshop	Participants	country	researcher / practitioner	domain
#1	P1	France	practitioner	sustainable design (digital)
#1	P2	France	mostly researcher	environmental impacts of ICT
#1	P3	France	researcher	environmental impacts of ICT
#1	P4	France	researcher	environmental impacts of ICT
#1	P5	Netherlands	practitioner	sustainable design (strategy)
#2	P6 (E1)	UK	mostly practitioner	sustainable design (product)
#2	P7	France	researcher	environmental impacts of ICT
#2	P8	France	practitioner	systemic/sustainable design
#2	P9	Germany	practitioner	systemic design (strategy)
#3	P10	France	researcher	systemic/sustainable design
#3	P11 (E3)	France	practitioner	sustainable design (digital)
#3	P12 (E4)	Germany	researcher	circular economy
#3	P13	Germany	practitioner	circular economy

Table 3. Online workshops' participants.

The workshops aimed to test and iterate on the prototype with different stakeholder groups, each with varying levels of knowledge and experience regarding rebound effects. The first group comprised primarily experts in indirect effects, the second group included designers specialising in sustainability and systemic design, and the third

group involved experts in the circular economy but not in rebound effects. Each workshop focused on a different case study, selected from the proposals submitted by participants prior to the workshop, allowing for diverse viewpoints and comprehensive feedback on the prototype. In order to avoid any unnecessary time wasting during the workshops, we selected simple case studies. The first group evaluated the implementation of a teleworking policy by a company, the second group evaluated the potential effects of an application to reduce food waste, and the third group worked on the implementation of a tax on returnable packaging (see appendices for more details). The sessions were recorded and transcribed. Formative evaluation was conducted using observations, feedback on the Miro boards, and group discussions.

Workshop activities	description
Prior to the workshop	Prior to the workshop, participants were invited to submit case study ideas, which included a description of a problem, an intervention, and a list of the stakeholders involved.
Opening	Presentation of the objectives and steps of the workshop.
Introduction	Each participant introduced themselves to the others.
Playing the cards	Each group worked on the selected case study using the cards provided, following the Workshop steps described in the Rebound Archetypes tool section.
Feedback	We collected spontaneous general feedback from the participants, and then asked them to answer specific questions (on the advantages and disadvantages of the cards, and on the contexts for using and not using them).
Designing an improvement	Finally, we asked participants to design an improvement to the cards and/or the workshop. This could involve changing or adding a step, a card, or any other element.

Table 4. Workshops' activities.

C. Playing the cards 15 min

1. Intervention (case study) and other examples

2. Stakeholders

3. Rebound effects

4. Impacts

Figure 5. Identification of the indirect effects and impacts on the Miro board (workshop 2).

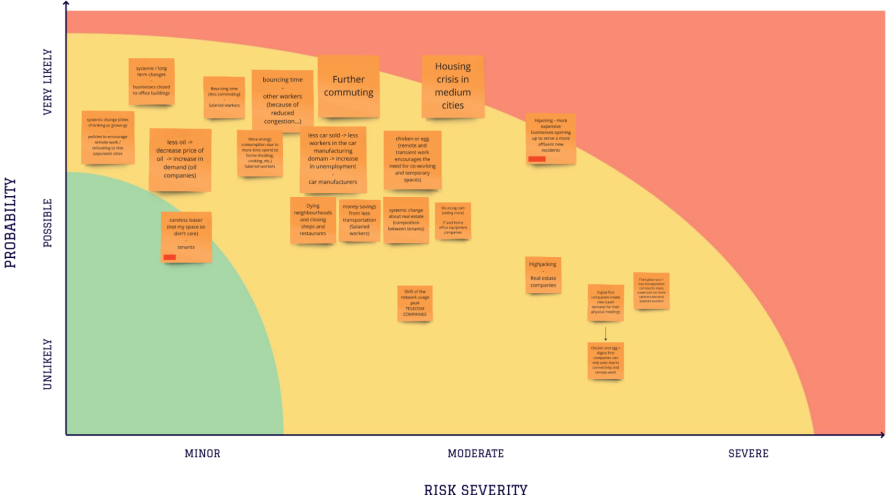


Figure 6. Risk assessment matrix on the Miro board (workshop 1).

Main insights from the interviews

Rebound effects are inherently systemic

As pointed out by (E4), rebound effects are systemic in nature. Indeed, they can be seen as a resistance of the socio-technical system (see the notion of *drivers*): *"It's the ways in which a system resists the change that you're trying to make that is counter to your goals."* This expert (E4) also mentioned the fact that rebound effects can be described using feedback loops, which is also stated and illustrated by Guzzo (2024).

Systemic designers usually do not consider the potential rebound effects that may emerge from their intervention

Systemic designers focus on the relationships within a system, trying first to understand a systemic situation and its different layers of meaning before trying to define an intervention. In other words, they usually think about *"finding the root causes"* of a current situation and the possible *"leverage points"* to intervene in a given system. However, according to (E4), they don't usually anticipate the possible rebound effects that might result from their intervention: *"that takes so much cognitive effort, that takes so much time, that takes so much modelling [...] by the time you get to that level of solutioning, you have already sort of complexed yourself out."* (E4)

Nevertheless, as indicated by (E4), this does not negate the value of anticipating potential rebound effects: *"I'm not trying to say that this is a problem we shouldn't solve. Absolutely."* In the context of political interventions, he argued that *"there might be an ethical obligation to at least have a pause before you really go and implement and then try to anticipate those second order effects."*

Perimeter of analysis

The direct and indirect rebound effects typically offset the specific intention behind the initial intervention. Higher-order indirect effects (e.g., systemic rebound) can have ripple effects that extend beyond the initial perimeter. According to (E4), decision makers are likely to be willing to discuss the potential rebounds within their perimeter. This raises questions: should the discussion of rebound be confined to the domain under consideration, or should the wider implications of the intervention be brought to the attention of decision makers? If the latter is the case, the question arises as to *"how do we bring the whole world into this problem?"* (E4). In fact, two dimensions of distance from the initial perimeter can be considered: change counteracting an initial intention *"How far away from the sort of local changes you're making we're getting"*, and other

(detrimental) changes outside the initial scope of intervention *“What order of magnitude of systems change are we talking about?”* (E4)

Challenges to address rebound effects

The first challenge in addressing rebound effects is the lack of awareness about this phenomenon. Many practitioners and researchers engaged in environmental sustainability are unaware of the existence of rebound effects, let alone designers who are not specialised in sustainability. For instance, (T1) stated: *“I didn't know anything about rebound effects until about six weeks ago when I started this job”*. Lack of awareness and knowledge amongst designers around sustainability issues has also been highlighted in literature *“even well-meaning designers have a limited conception of the tools and approaches necessary to design for sustainability and other important emerging issues”* (Design Council, 2021). Even for designers who are aware of rebound effects and would like to mitigate them, a major challenge is to contend with a lack of time and resources allocated to these subjects (E1, E3). (E1) informed us that the stakeholders (usually clients) seeking to have a positive impact on the environment generally do not think in a systemic way: they focus on carbon emissions and do not consider other impacts (extraction, biodiversity, etc.). Moreover, according to (E1), they are seeking a rapid and straightforward solution and tend to be overly idealistic with regard to social change. Finally, according to (E3), the most challenging aspect is not identifying or anticipating rebound effects but rather convincing other stakeholders and clients, as well as defining concrete strategies to mitigate the risks.

A current practice to address rebound effects

Among the experts interviewed, only the expert (E1) described a process and tools (which go beyond simple discussion) that she typically employs to address rebound effects in her practice, when project resources allow. First, the expert (E1) conducts a brief literature review (with examples of past rebound effects), then maps out the consequences with fellow designers (high-level brainstorming). Once the risks have been identified, the expert (E1) draws on the human-centred design framework and the principles of behaviour change. In workshops with stakeholders (clients), the expert (E1) provides illustrative examples to support the ideation and construction of potential intervention scenarios. Finally, when time permits, the expert (E1) conducts an evaluation of the order of magnitude of the impacts of each scenario, including any identified rebound effects.

Need for concrete systemic tools and examples

According to (E1) and (E3), systemic tools are typically of a high level of abstraction and lack practicality and applicability. They regret the lack of tools "*at the scale*" (E1) of the problems they face. It is not just a question of knowing how to apply systemic principles in concrete terms, but also of being able to convince stakeholders with something "*concrete*", "*more than words*" (E3), such as figures, orders of magnitude, past projects where there has been failure/success, etc. In accordance with (E3), in order for a systemic approach to be widely applied, it is necessary to provide guidelines: "*it's sad to say, but it has to be rated or checked, or it has to be measurable.*" (E3)

The de-dramatisation and unlocking of work on rebound effects

Discussions about rebound effects with novice stakeholders may be perceived as pessimistic, as no solution can be seen as perfectly satisfactory. (E1) suggests providing stakeholders with a series of examples of design interventions, including "*silly*" examples, to alleviate the anxiety and seriousness of participants and increasing their openness: "*engage people in a bit of fun and play and actually that seems to get people to think a bit more creatively*" (E1).

The role of context in the emergence of rebound effects

According to (E2), context is of paramount importance and is frequently underestimated. It is not possible to identify a singular solution that can be universally applied to all problems: "*if you move to just let's say one sustainable renewable material and now we do only one type of wood everywhere, that grows fast, this will be monoculture and it will not be sustainable.*" (E2)

Dealing with emergence and overcoming *analysis paralysis*

As outlined by (E2), it is impossible for designers and stakeholders to anticipate all possible rebound effects due to emergent phenomena in an open system at the macro level. Furthermore, experts (E2) and (E4) have argued that considering all possible future rebound effects could lead to cognitive overload for designers and stakeholders, or even to "*analysis paralysis*", making any intervention impossible. One possible way to address this is to plan to monitor the possible rebound effects: "*there will be rebound effects and it's just important to be aware and to continuously have a monitoring governance system in place.*" (E2)

A set of cards that becomes less necessary with increasing experience

It can be useful to embody some concepts and steps in a set of cards. However, as argued by (E4), the most important aspect is not the cards themselves (which are often placed in a closet) but rather to convey a mindset, a skill, and a methodology. The tool should be modular, adaptable to existing design processes, and less necessary with increasing experience of the designers, as they memorise the cards.

The Rebound Archetypes tool

Context and objective

Overall, the card-based tool aims to help users to anticipate potential rebound effects and reduce their risk before a design intervention is implemented (ex-ante). Our objective was to create a set of cards that would support a workshop facilitated by a designer for a client or within a company to enable collective reflection about indirect effects, risk identification, and decision-making. Building on the findings of the expert interviews, we made a series of choices that bounded and shaped the design.

Requirements and intentions

The intended audience for the cards are designers who are not experts in rebound effects and who are well-intentioned, i.e. interested in understanding and minimising the negative social or environmental impacts of their interventions. The cards should be flexible enough to be applicable to several possible situations (e.g., risk mitigation, alternatives comparison, awareness raising). However, we initially envisioned the cards to address risk mitigation of a given intervention that had already been planned or under design. Although the use of the cards could lead to a better understanding and knowledge, raising awareness of rebound effects is not the main objective of the cards. While the Rebound Archetypes cards are a playful tool, they were not designed to be a game with rules and game mechanisms. They are ideation cards that playfully support discussion and stimulate the generation of ideas regarding possible rebound effects and mitigation strategies.

Design rationale

The design includes several sets of cards to support the different steps in the decision-making process followed during the workshop. The cards and workshop steps are described below. The content of the cards is derived from a variety of sources, including literature, taxonomies (Bieser and Hilty, 2018; Bremer et al., 2023; Coroamă et al., 2020; Horner et al., 2016; and Roussilhe et al., 2023), authors' experience on several case

studies, and interviews. In regard to the identification of potential rebound effects, our objective is to facilitate the generation of ideas to consider as many risks of rebound as possible. To this end, we have included the largest list of rebound archetypes that we could derive from the sources, regardless of potential redundancy. Further iterations will contribute to the refinement of the list of possible rebounds. At this stage, we have not specified any categories, but this is a possibility for future consideration. The cards present concepts in a metaphorical manner, with a name and a corresponding illustration. The objective is to make these notions less serious and easier to understand. We also created a set of 'jokers' or 'wildcards' in the shape of prompt cards to guide the participants in thinking through aspects that could otherwise be overlooked or highlighting potential pitfalls.

The cards offer a variety of themes, examples or points for reflection. The ideas specific to the intervention under study generated by the use of the cards should be noted on sticky notes. We chose to use sticky notes to instantiate the cards because they allow participants to be more specific than just identifying a category of stakeholder, rebound, impact or strategy. The sticky notes allow them to jot down details and link to stakeholders and resulting impacts. Also, many instances of a particular type of rebound may result from the same intervention. Sticky notes can also make the tool reusable, without having to print the cards more than once. Our aim is that the cards will become less necessary for experienced users over time, as the process becomes familiar and embedded in their own design processes.

We planned that the outcome of the workshop would be a set of decisions that could lead to a roadmap of actions. For example, it might identify gaps in knowledge and therefore lead to actions such as 'conduct further research into the carbon emissions of technology X', 'involve stakeholder group Y in the design process', or 'use a systems modelling tool to calculate the impact of the proposed mitigation strategy'.

Workshop steps

The workshop in its current form (design V1++) has 7 steps:

1. **Identify intervention to be discussed.** Before the workshop, we asked participants to think about a design intervention they would like to work on. The first action of the workshop is to agree on the intervention and use the template to describe it.
2. **Identify and discuss stakeholders.** Next, the participants are asked to think through the stakeholders. The cards suggest groups of stakeholders and

participants should write on sticky notes any specific groups affected by their intervention.

3. **Identify possible rebound effects and dynamics.** The participants are asked to consider the potential effects of the intervention on the stakeholders identified. The cards can be used from the beginning as examples to help generate ideas (workshop 1) or as an aid after ideas have been created to help identify any areas not yet considered by the group (workshop 2 and 3). The effects can be organised in a number of ways, including as clusters around the stakeholders (workshop 1), in a format that is easier to read, such as a consequential tree (workshops 2 and 3, see Figure 5), or in a more systemic way, such as causal loop diagrams.
4. **Based on the rebound archetypes chosen, identify possible environmental or social impacts.** The cards in this set are based on the planetary boundaries and social foundations of the Donut Economics Model (Raworth, 2017).
5. **Assess the risk presented by those rebounds and impacts.** For this step we suggest the use of a risk matrix (see Figure 6) where one axis considers the likelihood of an impact and the other considers its severity. Participants are instructed to write down the potential impacts onto sticky notes so that they can be repositioned on the risk matrix as they discuss and negotiate their views. Here, the prompt cards ('jokers') provide advice on different considerations to be made while judging the likelihood and severity of the risks.
6. **Decide on the actions to take in relation to the intervention.** Once the position on the risk matrix has been agreed, the participants should decide whether the intervention is too risky and should be cancelled, whether there are few risks that could be mitigated, or whether there are few or acceptable risks and the intervention should be implemented and monitored.
7. **Explore possible mitigation strategies.** If there are risks that should be mitigated, the last step of the workshop is to generate ideas for changes that could improve the proposed intervention. The cards in this section provide some examples of mitigation actions.

Cards design

The current version of the cards (Cards design V1++)^[3] can be downloaded from the links on the footnote. It consists of four sets of cards, prompt cards ('jokers') to be used at decision-making stages of the process and rule cards described in Table 5.

Cards	Quantity	Colour	Description
Stakeholders	5	yellow	Suggests groups that should be considered in the activity. This might be users and non-users that will be affected by the intervention including non-human beings.
Rebound archetypes	13	red	Presents various rebound archetypes (trigger and effect) or indirect effects that may occur because of the intervention.
Impacts	21	purple	Lists some categories of environmental and social dimensions that may be impacted by the intervention. This is based on the planetary boundaries and social foundations of the Donut Economics Model (Raworth, 2017).
Risk assessment prompts	3	blue	Points for consideration when judging the risk of the impacts.
Decision prompts	4	green	Suggestions on how to deal with difficulties around making decisions.
Mitigations	11	green	Suggestions for actions to be taken to deal with potential rebound effects.
Rule cards	6	colour of the set	Explanations on how to use the cards on each step of the workshop.

Table 5. Description of the Rebound Archetype Card types.

In addition, a template is provided for users to take notes of details about the intervention they wish to tackle. This is supplemented with three pre-filled templates with examples of design interventions containing information about stakeholders,

^{3]} The Rebound Archetypes cards can be downloaded using the following links:

<https://lii.enac.fr/projects/rebound-archetypes-cards/>

<https://wp.lancs.ac.uk/paris-de/rebound-archetype-cards/>

rebound effects analysis and suggested mitigation actions. The complete set of Rebound Archetypes Cards is pictured in Figure 7.



Figure 7. All cards of the first version of the Rebound Archetype cards.

Anatomy of Rebound Archetypes cards

The cards were designed to encapsulate an idea or concept, stimulating discussion and providing support for reflection. Each card contains the following information (see Figure 8): the type of card (e.g., rebounds, stakeholders, mitigation), the number of the workshop process step at which it is to be used, the title of the card and an illustration. The Rebound Archetypes and Mitigation sets, as well as the prompt cards also include an explanation with questions or examples. We plan to include explanations for the other sets in version 2 of the cards.

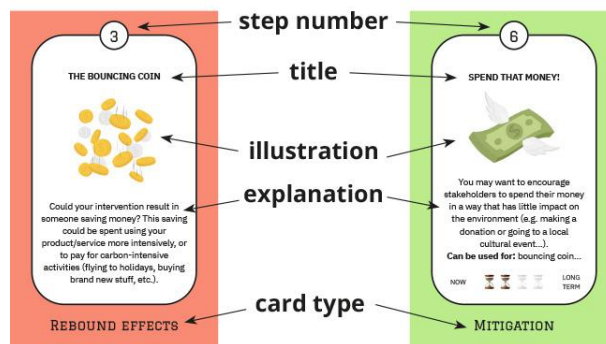


Figure 8. How information is organised on the Rebound Archetype cards.

The benefits of the cards from the participants perspectives

The participants described the activity as engaging (T2, P9) and enjoyable (T1,T2) and that using cards “*took some of the pressure off*” (T1) of taking part in such activity. They also identified the following themes where the cards were particularly useful.

Teambuilding

Participants from the group that tested the tool in person thought that the tools worked well for team building (T2) and the cards worked as a way to facilitate conversations (T1).

Providing flexibility

(T2) mentioned being able to apply the cards in a specific activity such as the intervention that was tackled during the pilot workshop session, but highlighted that the cards could be useful in a broader context, for example to make sense and plan how to deal with rebound effects of whole areas of their organisation. It was also thought that in addition to using the cards at the initial stage of a design intervention, the cards could be used as part of a yearly planning strategy for monitoring and reflection on the impact of their activities.

Enabling new ways to think

(T2) highlighted that the card tool could be used to enable new ways of thinking, in particular if stages were added to the facilitation process when participants were asked to think at certain points of the workshop from different points of view, perhaps using personas. (P9) also commented that the cards were “*great to shift some of the biggest flaws that we have in thinking*”.

Main findings

In this section, we present our findings from the study, including the pilot workshops and the online workshops. Each group exhibited unique dynamics, which influenced the nature of their discussions and interactions. Despite these variations, we have highlighted all key insights here to provide a comprehensive overview of the results.

The technical term *rebound effect* is too restrictive for the purpose of this tool.

As outlined in the Related Work section, the original technical term *rebound effect* is too restrictive for our purposes. In fact, our objective is to assist designers and decision-makers in identifying and addressing all the indirect effects (that are not apparent to

them) that may have a social and/or environmental impact perceived as negative. As stated by (P3): "*you mapped out negative indirect effects.*" However, this term has gained considerable popularity and is beginning to be increasingly identified and understood by researchers and certain professionals (much more so than the term *indirect effects*). Moreover, it seems that practitioners are more interested in the practical aspects than in the terminology. This is why we have kept the term *rebound*, even if we include more broadly all the potential indirect consequences that are perceived as 'negative'.

The identification of rebound effects necessitates the identification of other (potentially positive) effects.

As presented in the Related Work section, rebound effects are intertwined in causal chains. A series of consecutive effects can give rise to a trigger effect (which is often positive), which, through a rebound mechanism, leads to one or more rebound effects and their impacts. During the online workshop sessions, our objective was to focus on the negative effects, with the aim of assessing their risk and considering potential mitigating strategies while limiting the scope of the workshop (given that the expected positive effects are supposed to be already known by the participants). A number of participants (P2, P3, and P4) expressed concern that this approach might prevent us from identifying certain risks associated with rebound effects: "*some rebound effects or some cards cannot happen if there is not a positive indirect effect*" (P3).

From this, it can be concluded that it would be beneficial to provide participants with the opportunity to represent all relevant effects, potentially in the form of a causal loop diagram (Haraldsson, 2004) if this is deemed to be appropriate. The Rebound Archetypes cards (step 3) could thus assist users in identifying potential trigger effects and the associated rebound effects. In a future version of the cards, as proposed by (P11), we could clearly differentiate the trigger effects (e.g. on the front) and the associated potential rebound effects (e.g. on the back).

The 'positive' and 'negative' valences may vary depending on the values of the stakeholders.

The distinction between 'positive' and 'negative' was a recurring theme during the online workshops. As previously discussed, certain effects that are perceived as 'positive' can give rise to 'negative' rebound effects. Furthermore, a rebound effect is not necessarily 'negative'. The participant (P3) provided an illustrative example of electric bikes, which have led to an increased use but which remain 'positive' because they have substituted more car journeys than regular bicycle journeys or walking

journeys. Furthermore, the participant (P12) highlighted that a direct rebound effect can be considered 'negative' when it concerns consumers, but 'positive' when it occurs elsewhere in the value chain. For instance, if it reinforces the use of recycling or reuse. For a given effect, there may be 'winners' and 'losers', as emphasised by (P4) and (P13). In fact, it is only possible to discuss the negative or positive value of indirect effects by assessing their impacts (step 4). If we only consider each environmental or social impact individually, we can describe it as 'negative' without ambiguity (e.g. increase in GHG, pollution, land use change, reduction in access to drinking water, etc.). However, in general, an intervention has several effects, which have several impacts, some of which may be perceived as positive, and others as negative. The aggregation of these impacts necessitates a prioritisation process, which is highly dependent on the values of the stakeholders. (P2) recommended that these values be made explicit before or during the workshop, (P4) suggested that the risk assessment activity (step 5) be made the most interactive and discussed part of the workshop, and (P3) and (T2) suggested that personas could be used to adopt several points of view during the risk assessment.

Can we identify some risks without mapping all the effects?

As previously discussed, it can be challenging to anticipate the negative impact of an effect a priori. In general, 'expert' workshop participants attempted to represent a 'complete' reality, encompassing all potential effects, in order to assess the overall situation, rather than focusing on risk prevention, by representing potential undesirable trajectories. For example, (P13) said, in reference to the indirect rebound effect, that people *"could also spend this money on sustainable technology"*. In fact, the first approach seeks to answer the question: does this intervention have 'positive' impacts overall? Whereas the second approach seeks to answer the question: does this intervention risk having 'negative' impacts, and can these be mitigated? Although our tool is primarily designed to address the second question, there is a need to further develop its modularity. This would allow it to be used in a variety of ways, from provoking reflection to consolidating causal loop diagrams. This would help to meet the pragmatic needs of novice professionals and the rigorous demands of expert researchers.

Activities complementary to the Rebound Archetypes tool.

It is not the intention of this tool to provide a comprehensive account of all possible systemic reflections and steps. Proposing a single generic method would be almost antithetical to systemic thinking, insofar as this approach recognises the organic nature of human processes. This is why our objective is to develop a tool that can be integrated

into existing processes without attempting to encompass all the fundamentals of systemic thinking or to 'reinvent the wheel'. Nevertheless, we are able to provide recommendations regarding the steps and tools that should be implemented prior to the utilisation of our tool, based on the feedback that we have received throughout our study. In particular, if the tool is to focus on the risks associated with a given solution or intervention, a problem-based approach should be adopted prior to arriving at the proposed solution and its evaluation. As indicated by (P2), it is essential to define, in collaboration with relevant stakeholders, a desirable future trajectory that can serve as a foundation for the intervention (Hancock & Bezold, 1994). This should be accompanied by a sharing of the values (Donia & Shaw, 2021) underlying this vision and the choices that flow from it (P2, P3). In a more pragmatic vein, it may also be beneficial to provide participants with some preliminary knowledge (e.g. environmental impacts of that industry or type of product/service, proposed benefits, resources that are used, type of consumers/users) if they are not already familiar with the subject matter, as well as other illustrative examples of interventions with rebound effects (P1, P11). However, prior knowledge of rebound effects typologies is not needed, as the cards provide the necessary support and information. (T1) observed that you can "*lean on the cards*" to have the information you need to talk about rebound effects.

The complexity of environmental impacts.

As observed by (P2) and (P13), identifying the impacts, particularly environmental impacts, associated with an effect is not a straightforward task, even for practitioners working on sustainability. Furthermore, the impacts may be numerous and interconnected. For instance, (P13) shared with us: "*I'm doing education for people who are working on LCAs. They should know the impacts inside out and they just don't. [...] They don't know how things are connected in the environment.*" In order to assist participants in identifying the impacts, (P2) proposed the involvement of an expert, while (P13) suggested the provision of specific pedagogical explanations during the workshop.

The lack of agency: how to deal with powerlessness?

A number of participants in the workshops stated that the main obstacle often lies in the stakeholders' lack of agency. In their view, it is not sufficient to be aware of the risks or to have identified the optimal course of action; rather, it is critical to possess the authority to implement these decisions. For instance, some of the proposed mitigation or prevention techniques in step 6 can only be implemented on a large scale by political decision-makers, such as regulations and quotas. Consequently, a 'joker' card (Allies

card) was designed to encourage participants to seek allies when they lack the agency to take action at their level. In addition, (P2) proposed several levels of agency depending on the role for a given stakeholder: *"You could maybe build some cards about the type of agency that people have... because, like, you always have agency: even if it's something about political decisions, you have agency as a citizen, you have agency as a lobbyist."* (P2)

Discussion

This study has provided valuable insights into the utility of using a card-based tool to facilitate discussions on rebound effects in design contexts with a systemic perspective. We found that the use of the cards enabled groups to engage in a playful yet structured manner, preventing stagnation in discussions, or *analysis paralysis*. This approach proved effective in helping participants identify and plan interventions for addressing rebound effects. Furthermore, the cards were instrumental in clarifying the mechanisms behind rebound effects and distinguishing between rebound effects and impacts. Our primary contribution lies in advancing the understanding of how to identify and manage potential rebound effects into a design process. By leveraging the cards, participants could collectively think through the complex indirect consequences of design decisions, leading to more informed design and strategic planning.

One of the questions that we were initially uncertain about, and which we explored throughout our study, was the most appropriate context and time to use the cards. For the cards to have the most significant impact, we recommend their use during the research and ideation phases of the design process, particularly when the focus is on a specific design intervention. The effectiveness of the cards is enhanced when utilised by a cohesive group working collaboratively on an intervention, ensuring a shared understanding and collective approach to mitigating rebound effects.

Our approach aligns with design thinking and a 'designerly way of knowing' principles (Cross, 1982). Initially, we developed the cards based on both explicit knowledge (such as taxonomies) and implicit knowledge (including examples and case studies). Through iterative testing and validation, we separated the rebound mechanisms cards from their corresponding impacts into two different sets of cards and workshop steps. In hindsight, our framework naturally fits within a theoretical model encompassing the sequence of triggers, rebound mechanisms, rebound effects, and subsequent impacts (Guzzo et al., 2024).

While our study highlights the value of the card-based tool for discussing rebound effects and planning design strategies to mitigate them, it is important to recognise its scope and limitations. These cards are not designed to be played as a game, with game mechanisms and rules, nor are they intended to raise public awareness of rebound effects. They are not designed to represent or measure the magnitude of existing rebound effects, nor to judge whether an intervention is 'good' or 'bad', but rather to anticipate potential rebound effects and to prevent or mitigate the most serious and likely ones. These cards cannot help predict future outcomes, but they can help participants imagine and prepare for different possible outcomes.

We focused on a common scenario where a designer challenges a well-intentioned client's pre-designed solution. The workshop facilitated by the cards has been designed as part of the prototyping process, whereby the initial prototype is assessed, akin to a design walkthrough. Ideally, however, potential rebound effects should be considered very early in the design process. In this case, designers could use only the rebound archetypes cards to anticipate and prevent potential rebound effects at very early design stages (before defining a first prototype). This may require iteration both on the cards and in the workshop process. In any case, to be most effective, the cards should be used alongside other systemic tools and best practices. For example, before defining an intervention to be evaluated, stakeholders should have adopted a problem-oriented approach. Also, before (or during) the use of the cards, we recommend involving a diverse and representative team, sharing values between stakeholders using a value-based design framework, and defining a desirable future and a pathway to it using future studies methods. The description of the effects resulting from the intervention can take the form of a consequence tree (see Figure 5) or a causal loop diagram, depending on the project and the needs of the stakeholders. Depending on the context, a quantitative dynamic model based on hypotheses could be used, if necessary, to compare the magnitude of impacts and to compare the potential effects of different mitigation strategies. Once the cards have been used to assess potential rebound effects and outline initial plans, other tools and processes should be used to refine these plans, define a roadmap, monitor the situation and communicate with a wider audience.

Our online workshops also had limitations. Unlike the in-person pilot workshop, the online sessions were not conducted in the field. Participants were unfamiliar with each other and the topic, and were discussing a pre-defined intervention. Some feedback

was specific to this setting and may not arise in real-life scenarios. For example, one participant commented that *“direct or indirect really depends on your position in the value chain”* (P12). In practice, participants would typically be aware of their role and position in the value chain. In addition, our evaluation methods had limitations. Like most of the analogue tools reviewed in (Peters et al., 2021), our evaluation is descriptive, relies on observations by us, the tool creators, is conducted in controlled environments rather than in real-life settings, and lacks comparative controls. As noted by Clatworthy (2011), it is difficult to distinguish the impact of the cards from the overall positive team-building effects of collaborative workshops, and to determine whether solutions are constrained without controlled testing procedures.

This study provides avenues for future research, for instance to evaluate to what extent the tool can help drive decisions or action within an organisation. The difference between online and in-person settings could be better explored. In addition, further research could explore the value of the cards in other contexts, such as awareness-raising or education, and adapt the cards for these contexts. The development of a collaborative platform where designers can create new cards, add examples and develop specific workshops could be valuable. Contributions from designers could be used as probes, facilitating continuous improvement and a deeper understanding of design practice in relation to rebound effects. It could also help to build a community of practitioners around rebound effects.

Conclusion

Recognising the importance of understanding and mitigating rebound effects, this paper presents the first design of the Rebound Archetypes tool, a card-based tool designed to help designers and decision-makers think through these effects in ex-ante investigations. Following a review of the relevant literature, our research explored designers' current practices and challenges in considering and addressing rebound effects in their design processes through semi-structured interviews. Based on the insights from the literature and expert interviews, we prototyped a card-based tool and investigated how it could improve designers' and stakeholders' understanding, identification, anticipation and mitigation of rebound effects, and what insights could be gained from observing stakeholders using the tool. Our study demonstrates the effectiveness of a card-based tool in facilitating discussions about rebound effects in design contexts. The tool encouraged engaging discussions that helped participants identify and plan interventions for rebound effects. The cards clarified the mechanisms

and distinctions of rebound effects and fostered the integration of these considerations into design processes. Participants found the card activity engaging and enjoyable, noting that it reduced the pressure of participation. The cards were particularly useful for team building and facilitating conversations. In addition, the cards enabled new ways of thinking by encouraging different perspectives and addressing common cognitive flaws. However, the tool and the standard process could be improved. Our participants stated that identifying potential negative indirect effects requires understanding the entire causal chain, including positive trigger effects, possibly using causal loop diagrams. Workshop feedback indicated that the perception of impacts as positive or negative can vary between stakeholders, highlighting the need to clarify values, define desirable trajectories and discuss impacts collaboratively. Finally, recognising the complexity of environmental impacts and the varying levels of agency among stakeholders is critical to effectively identifying and mitigating the risk of rebound effects. Future research could explore the use of the Rebound Archetypes tool in different contexts and the development of a collaborative platform for continuous improvement.

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Appendix A: Semi-structured interview questions

Your work

Could you tell me about your professional background and how you came to be in your current role?

What are the main areas of work you are involved in?

Your relationship with sustainability and systemic design

How much does your work focus on sustainability? from 0 = “none” to 5 = “all of it”

Can you elaborate?

How do you consider yourself regarding systemic design / systems thinking? from 0 = not interested to 4 = knowledgeable and 5 = expert

Can you elaborate?

Rebound and indirect effects

Before this interview, did you know the concept of rebound effects? And did you know the different types of direct and indirect effects?

Rebound and indirect effects in your work

In your work, do you remember project(s) involving rebound effects? indirect effects?

In this project/these projects, did you consider rebound effects? Did you consider all types of direct and indirect effects?

- why?
- in which situations?
- did you deal with existing rebound effects or did you anticipate potential rebound effects?

In this project/these projects, did you communicate/work on it with stakeholders?

- how?
- what are the difficulties?
- what is helping (if any)?

In this project/these projects, did you try to anticipate unintended consequences / rebound effects?

- how?
- what are the difficulties?
- what is helping (if any)?

In this project/these projects, did you try to mitigate unintended consequences / rebound effects?

- how?
- what are the difficulties?
- what is helping (if any)?

Opening

Are there any other comments would you like to add in relation to what we discussed?

Appendix B: Illustration of the work carried out during the workshops

Table 6 provides illustrative examples of rebound effects and mitigation strategies identified by the participants for each intervention under consideration during the online workshops.

Intervention under consideration	Potential rebound effect identified by the participants	Ideas for mitigating the risks identified by the participants
<p>Workshop #1: To reduce the impact of commuting, a company is considering allowing and encouraging teleworking.</p>	<p>economic rebound effect for employees and the company</p> <p>systemic change in real estate, with a shift in residential patterns</p> <p>development of co-working facilities, with the associated impacts (including transport)</p>	<p>manage the impact on cities through caps and quotas to reduce the sudden change</p> <p>encourage businesses to change their business model to provide value back to the local economy</p>
<p>Workshop #2: A company is considering designing a matchmaking application to make it easy to buy perishable items that would otherwise be discarded or wasted.</p>	<p>overcompensation because customers may feel less guilty about buying more than they need (resulting in more waste at home)</p> <p>supporting the overall phenomenon of wasted food - "metabolism"</p>	<p>education about the fact that you should use food before it's expired</p> <p>tax food waste, make it more expensive</p> <p>redesign the value chain</p>
<p>Workshop #3: Policymakers are considering a deposit on single-use plastics: consumers would pay a tax when they buy the bottle and get it back when they return it.</p>	<p>beverage manufacturers could introduce new one-use formats that are not deposit-covered</p> <p>will not push for stricter regulations to ban plastics</p> <p>the government collection system would receive a lower quality of PET plastic, making it less valuable for recycling purposes</p>	<p>put in place safeguards to prevent companies from using new one-use formats</p> <p>put in place safeguards to ensure that this does not prevent the introduction of regulations to limit plastic</p> <p>co-designing the project with experts from the government collection and recycling system</p>

Table 6. Examples of rebound effects and mitigation strategies identified for each intervention studied during the online workshops.