HAL
open science

A Methodology and a Tool to Support the Sustainable Design of Interactive Systems

Laetitia Bornes

To cite this version:

Laetitia Bornes. A Methodology and a Tool to Support the Sustainable Design of Interactive Systems. CHI EA '23: Extended Abstracts of the 2023 CHI Conference on Human Factors in Computing Systems, Apr 2023, Hamburg Germany, Germany. pp.1-5, 10.1145/3544549.3577055 . hal-04088784

HAL Id: hal-04088784

https://enac.hal.science/hal-04088784v1

Submitted on 17 Jul 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

A Methodology and a Tool to Support the Sustainable Design of Interactive Systems

Adapting systemic design tools to model complexity in interaction design

Laetitia, L.B., Bornes
ENAC & ISAE SUPAERO
laetitia.bornes@isae-supaero.fr

ABSTRACT

Sustainable HCI was initially structured along two axes: sustainability in design, i.e. reducing the material impact of software and hardware, and sustainability through design, i.e. influencing user behavior to reduce energy consumption. These approaches have been criticized for being reductive and insufficient in the face of the systemic problem of ecological transition. Some voices in the HCI community call for a broader consideration of non-human aspects in HCI and argue that new methods and tools should be developed for this purpose. The thesis aims at proposing a methodology to understand the interactions between the system to be designed (e.g. agricultural robot) and the dynamics of the socio-technical and social system (e.g. the agriculture and food sectors), in order to avoid simplistic solutions that could be counter-productive (e.g. rebound effect). It draws on the methods, tools, and techniques of systemic design (a recent field of research that brings together design and systems thinking) in order to build, with the stakeholders and the help of experts, a model of the socio-technical system, its dynamics, and its possible interactions with the system to be designed. The aim is not to build a "digital twin" of the socio-technical system from which one could predict its evolution, but rather to co-build a handmade and approximate model to support debate, to inform decisions, and to compare scenarios. To this end, the thesis proposes a "quali-quantitative" modeling tool based on the formalism of causal loop diagrams.

CCS CONCEPTS

• **Human-centered computing** → Human computer interaction (HCI); HCI design and evaluation methods; Interaction design; Interaction design process and methods.

KEYWORDS

Sustainability, Climate change, Modeling tool, Socio-technical and social systems

ACM Reference Format:
Laetitia, L.B., Bornes. 2023. A Methodology and a Tool to Support the Sustainable Design of Interactive Systems: Adapting systemic design tools to model complexity in interaction design. In *Extended Abstracts of the 2023 CHI Conference on Human Factors in Computing Systems (CHI EA '23), April 23–28, 2023, Hamburg, Germany.* ACM, New York, NY, USA, 5 pages. https://doi.org/10.1145/3544549.3577055

Permission to make digital or hard copies of part or all of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for third-party components of this work must be honored. For all other uses, contact the owner/author(s).
CHI EA '23, April 23–28, 2023, Hamburg, Germany
© 2023 Copyright held by the owner/author(s).
ACM ISBN 978-1-4503-9422-2/23/04.
https://doi.org/10.1145/3544549.3577055

1 INTRODUCTION

In the article "After Interaction", Alex Taylor [17] urges HCI designers to defocus from discrete user-machine interaction and think about the impact of their design within the complexity of the real world. He illustrates his point with the example of London's public rental-bike scheme. The challenge for an HCI designer would be to provide the public with quick and easy ways to rent the bikes. But, in a context of gentrification, the choice of locations for the bike's docking stations and the 30-minute free use limit has created hubs and left unintended consequences (deepening inequalities).

Material culture [21] has highlighted the power of artefacts to reflect our culture and to influence us as individuals. This suggests that design has great importance in the ecological transition, the biggest challenge facing our society. Sustainability cannot be based on technological solutions [3], but designers must take responsibility as part of the problem and as a possible part of the solution [18]. HCI designers, who aim to address human problems [11], must now place sustainability at the heart of their concerns [1].

Sustainability research efforts in HCI were initially focused on energy efficiency, life-cycle optimization and persuasive design (mainly by presenting indicators to users to motivate them to save energy). Within the HCI community, some voices recognize that the current approach, which focuses on the material impact of artefacts, is reductive and insufficient in the face of this systemic problem and that the community needs to develop tools and methods for this purpose [3, 10, 13].

This thesis proposes to draw inspiration from systemic design methods (see section 3 & 4) to apprehend the complex challenge of sustainability in the design of interactive systems. Systemic design is a new field of research at the intersection of design and systems thinking, which develops methods and tools to address complex and multi-scale problems at the social and sociotechnical level. We argue that the scale of the socio-technical system can (and should) be taken into account in the design of interactive systems. For example, it may be useful to understand the issues of the agricultural sector (socio-technical system) when designing agricultural robots (interactive systems). By understanding the contexts in which the designed system will be placed, and its possible impacts at scale, one could avoid simplistic solutions that could be counterproductive.

Because of a difference in the scale of the unit of intervention (see section 3), we believe it is necessary to adapt the tools of systemic designers to the needs of interactive system designers. To facilitate the explicit recognition of systemic issues by interactive system

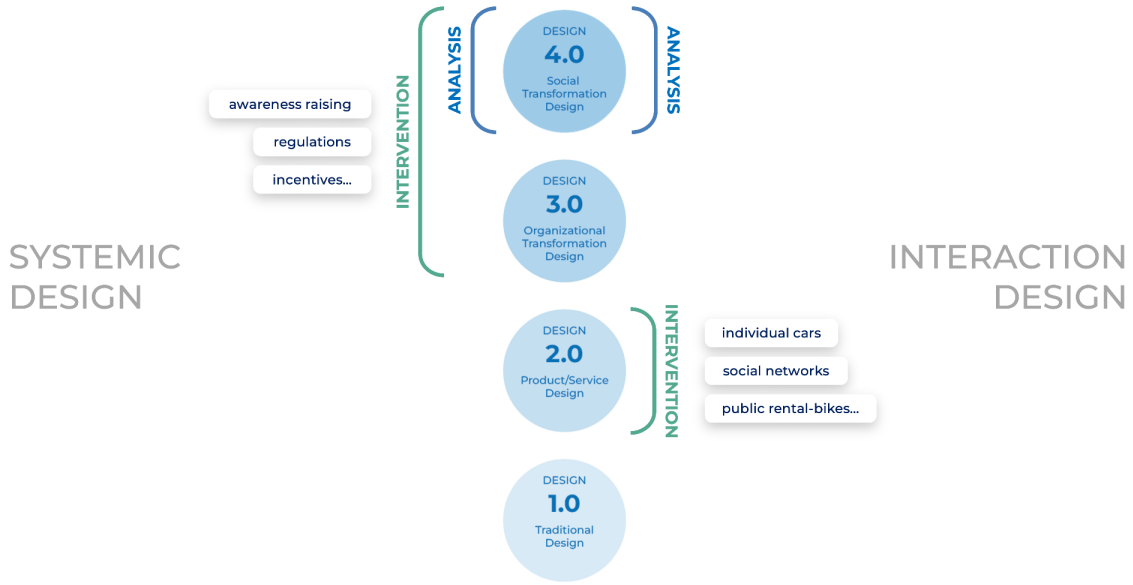

Figure 1: Levels of design in systemic and interaction design: extending the analysis to the social level. Inspired by Mapping design process to challenge complexity [8].

designers (without the need to master theories of systems thinking), we suggest the perspective of "quali-quantitative" modelling.

2 THE NEED FOR A SYSTEMIC METHODOLOGY IN SUSTAINABLE HCI

HCI has gradually started to consider the issue of sustainability over the last two decades. Sustainable HCI was initially structured around two axes: "sustainability in design" and "sustainability through design" [11]. "Sustainability in design" focuses on reducing the energy consumption of terminals and interfaces (fewer requests, page loads, dark mode, etc.), and reducing the impact of the device life cycle. "Sustainability through design" consists of influencing user behavior (through persuasive design) towards more sustainable choices. Mainly by presenting consumption information ("eco-feedback") to guide daily decisions (heating temperature, washing machine start time, etc.).

The improvement of energy efficiency starts from a good intention, but it usually provokes a counter-productive phenomenon now unfortunately well known as the "rebound effect" [19]. By improving the efficiency of car engines, people save on fuel and can afford to drive more (live farther away from work): it provokes a change in behavior at scale, and we observe an overall increase in fuel consumption [22].

Both axes of sustainable HCI have been criticized, especially for their "technological solutionism" and their "reductive" approach [2]. New axes of sustainable HCI developed to "move beyond simple models to grapple with the full multi-scalar complexity of 'wicked' sustainability problems" [16]. Sustainable Interaction Design invites us to rethink HCI methods, considering that "unsustainable behavior is often [...] a problem caused not by bad users but by bad design" [5]. New voices are claiming, through "more-than-human design" [6], the need to broaden the human-centered focus to a wider perspective [13]. However, the methods to implement these new guidelines are still to be built [3].

3 THE SYSTEMIC DESIGN METHODOLOGY AS A SOURCE OF INSPIRATION

Systemic design is an emerging approach that links systems thinking and design to develop "novel perspectives, processes, ideas and even theories" [15] to address complex, systemic problems. This growing practice mainly addresses societal problems and situations, operating at the level of "public policy, urban planning and habitability, food security, equitable economics, community sustainability, ecologically sensitive energy, and healthcare systems" [7]. Based on Richard Buchanan's [4] definition of four universal orders of design (1- Artifacts and communications, 2- Products and services, 3- Organizational transformation, 4- Social transformation), Jones [7] refers to four levels of design and places systemic design on levels 3.0 and 4.0 (see Figure 1).

We believe that the systemic issue of sustainability can and should be considered in the design of products, and especially of interactive systems. This means extending the unit of analysis beyond the unit of intervention (design 2.0), up to a societal level (design 4.0), as represented in Figure 1. For this, we propose to draw on the methods and tools developed by the systemic design community. However, these methods and tools are designed by and for "systemic designers". As mentioned, these, unlike interactive system designers, operate primarily at the scale of organizations and social systems (through policy, strategic decisions, etc.). For this

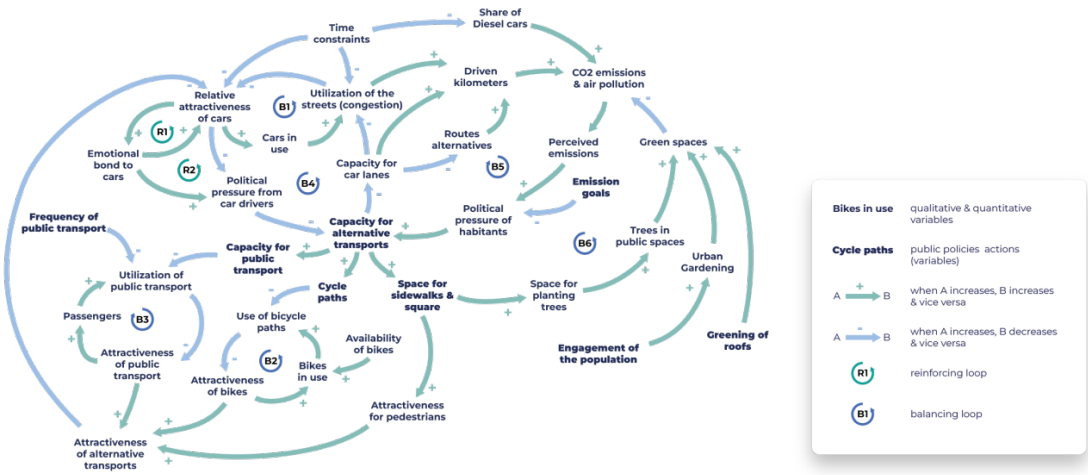

Figure 2: Causal loop diagram representing the public policies of the city of Paris to address climate change [20].

reason, we think that we need to adapt systemic design methods to the needs of HCI.

4 ADAPTING THE SYSTEMIC DESIGN METHODS AND TOOL

Systemic design methodology, which aims to decentralize design from the individual and adopt a system-wide view, is generally developed in seven steps: 1. Framing the system; 2. Listening to the system; 3. Understanding the system; 4. Defining the desired future; 5. Exploring the possibility space; 6. Designing the intervention model; 7. Fostering the transition [23]. Stages 1 and 2 use research techniques already known in the HCI field or very close to it, such as observations and interviews, with the social system rather than an individual user as the object of study. For this reason, our work focuses on the following steps, and in particular step 3. Indeed, systemic designers represent the social system, while HCI designers must represent and understand the interactions between the social system and the system to be designed.

We analysed four main tools used by systemic designers to represent systems, from the most qualitative and informal to the most quantitative and formal: the system map [23], gigamaps [14], causal loop diagrams [9] and leverage analysis [12]. Based on this study, we propose to use the formalism of causal loop diagrams to represent the dynamics of the social or socio-technical system of interest and its interactions with the system to be designed. Causal loop diagrams [9], inherited from system dynamics, are formal representations of the influences and feedback loops within the system of interest. Social systems cannot be reduced to quantitative data, but most of the problems of climate change are physical (planetary limits, carbon footprint, etc.). This formalism (see Figure 2) allows to combine data of different nature, both quantitative (e.g. carbon footprint, number of passengers) and qualitative (e.g. attractiveness, political pressure). Moreover, we believe that this formalism can guide beginners, who do not master the underlying theories of systemic design, to represent the system, to understand it, and to find opportunities and leverages.

Our objective is to propose an interactive tool (see Figure 3) that could help, based on the field study, the support of experts and other stakeholders, to:

- Represent the dynamics of the social or sociotechnical system of interest (e.g. agricultural sector), with a formalism close to the causal loop diagrams, but enriched with orders of magnitude, thresholds, delays, etc. For example, represent the impact of pesticide use on pests in the short term (destruction) and long term (resistance).
- Represent the impact of the system to be designed (e.g. agricultural robots) on the social or socio-technical system. For example, the reduction of pesticide use by mechanical weeding, but also the possible rebound effects due to changes in farmers' practices.
- Compare scenarios through simulation by looking at trends over time in variables of interest, such as carbon balance, soil health, and farmers' quality of life indicators.

The aim is not to build a "digital twin" of the socio-technical system from which one could predict its evolution, but rather to co-build a handmade and approximate model to support debate, to inform decisions, and to compare scenarios. The risk of models is often the overconfidence in the results, especially in opaque approaches based on large amounts of data, such as machine learning. Our prospective approach is exactly the opposite: since the data does not yet exist, it is the users of the model who explicitly build it on the basis of field data, and they therefore know the limits of the model.

5 RESEARCH APPROACH AND STATUS

5.1 Research approach

Our research objective is to facilitate the understanding, anticipation, and triggering (when desired) of the systemic impact of interactive products by manipulating systemic influences in a virtual world (modeling and simulation). Taking into account the systemic consequences of interactive systems design is not (yet) a common

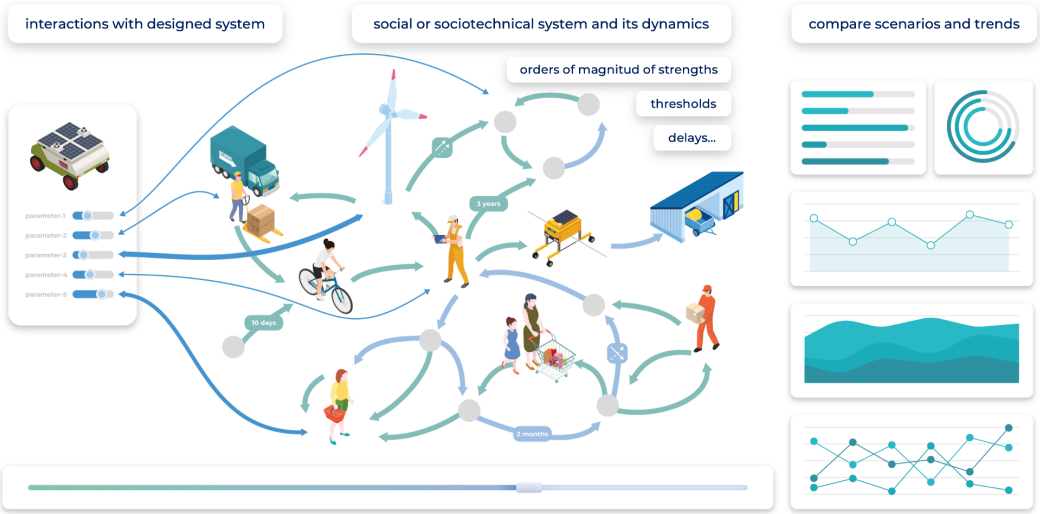

Figure 3: Abstract representation of the "quali-quantitative" modeling tool.

practice: designing the modeling tool requires identifying the need, but it is difficult to collect the need without having a tool to present as a discussion support. Similarly, the expected users are mainly designers and decision makers, but this will probably depend on each case study, and it is not impossible that the method and the tool could be of interest to other users, such as political actors. The approach of this research is therefore very exploratory, and we have favored a bottom-up approach, which consists in focusing first on the modeling tool (keeping in mind the systemic design methodology), and in bringing out the methodological guidelines iteratively by using the tool on different study cases. The thesis thus aims at three contributions: the "quali-quantitative" representation formalism of the social or socio-technical system dynamics, a prototype of the "quali-quantitative" modeling tool, and the formulation of methodological guidelines for the model construction.

5.2 Results and contributions to date

In order to bring out the general objective, we began by studying the literature and we carried out exploratory interviews with interactive system designers (engineers and designers), system architects, and a systemic designer. This allowed us to highlight the potential of systemic design methods for a systemic consideration of the ecological issue in the design of interactive systems. We presented a paper on this at the RSD11 conference in October 2022 [2].

To start qualifying the need, we worked on an academic case study of an autonomous energy airport in the south of France. The project consisted in powering the airport with local energy production (photovoltaic panels in the surrounding agricultural areas and wind turbines on communal land). We used several existing generic modeling tools (including Simulink and InsightMaker) to model the possible interactions of this airport system with the local social system: the financial compensation system for the farmers and the municipality, the impact on the attractiveness of the area and thus the traffic, but also the impact of possible oppositions and demonstrations due to the visual footprint of the installations... This allowed us to bring out the first needs of "quali-quantitative" modeling and to identify the weaknesses of the existing tools. On this basis, we started to define the "quali-quantitative" formalism and the main concepts of our tools, and we presented them to a sociologist and an expert in quantitative modeling of social systems to collect their feedback. We are currently preparing experiments to evaluate the "quali-quantitative" modelling formalism by designers. We are also laying the first foundations for a prototype tool.

5.3 Expected next steps

By April 2023, we expect to have conducted our experiments on the evaluation of the quali-quantitative formalism and analyzed the results, which we would like to present by submitting a publication. We will hopefully have a very first prototype of the tool, and a first simple modeling example in the agricultural field.

Our objective will then be to test this prototype on different case studies (including the academic case study of an autonomous energy airport, and an industrial case study in agricultural robotics) in order to: iteratively improve the prototype itself, bring out good practices in the methodology to build the model, such as the definition of the perimeter of the model, the stakeholders to be involved at different stages, etc.

Once the prototype has reached a certain level of maturity, we would like to conduct experiments in order to evaluate the added value of the modeling on the understanding, anticipation, and triggering (when desired) of the systemic impact of interactive products, and to present the results in a publication as well.

The long-term goal of the methodology is to enable interactive systems designers, and more broadly socio-technical systems actors, to make better design choices to have a conscious and positive impact on a global scale. Given the time scales of sociotechnical and social systems and the uncertainties of the real world, it will be difficult to validate the effectiveness of the whole methodology.

Assessing its value will take years: by applying the methodology to many projects and conducting a long-term study.

REFERENCES

[1] Eli Blevis. 2007. Sustainable interaction design: invention & disposal, renewal & reuse. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, ACM, 503–512. https://doi.org/10.1145/1240624.1240705

[2] Laetitia Bornes, Catherine Letondal, and Rob Vingerhoeds. 2022. Could Systemic Design Methods Support Sustainable Design Of Interactive Systems? .

[3] Christina Bremer, Bran Knowles, and Adrian Friday. 2022. Have We Taken On Too Much?: A Critical Review of the Sustainable HCI Landscape. *CHI Conference on Human Factors in Computing Systems*, ACM, 1–11. https://doi.org/10.1145/3491102.3517609

[4] Richard Buchanan. 1992. Wicked Problems in Design Thinking. 18. https://doi.org/10.2307/1511637

[5] Carl DiSalvo, Phoebe Sengers, and Hrönn Brynjarsdóttir. 2010. Mapping the landscape of sustainable HCI. *Proceedings of the 28th international conference on Human factors in computing systems - CHI '10*, ACM Press, 1975. https://doi.org/10.1145/1753326.1753625

[6] Elisa Giaccardi and Johan Redström. 2020. Technology and More-Than-Human Design. *Design Issues* 36, 4: 33–44. https://doi.org/10.1162/desi_a_00612

[7] Peter Jones. 2020. Systemic Design: Design for Complex, Social, and Sociotechnical Systems. In G.S. Metcalf, K. Kijima, and H. Deguchi, eds., *Handbook of Systems Sciences*. Springer Singapore, Singapore, 1–25. https://doi.org/10.1007/978-981-13-0370-8_60-1

[8] Peter H. Jones. 2013. *Design for care: innovating healthcare experience*. Rosenfeld Media, Brooklyn, N.Y.

[9] Daniel H. Kim. 1992. Guidelines for Drawing Causal Loop Diagrams. *The Systems Thinker* 3, 1: 5–6.

[10] Bran Knowles, Oliver Bates, and Maria Håkansson. 2018. This Changes Sustainable HCI. *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*, ACM, 1–12. https://doi.org/10.1145/3173574.3174045

[11] Jennifer C. Mankoff, Eli Blevis, Alan Borning, *et al.* 2007. Environmental sustainability and interaction. *CHI '07 Extended Abstracts on Human Factors in Computing Systems*, ACM, 2121–2124. https://doi.org/10.1145/1240866.1240963

[12] Ryan Murphy and Peter Jones. 2020. Leverage analysis: A method for locating points of influence in systemic design decisions. *FormAkademisk - forskningstidsskrift for design og designdidaktikk* 13, 2. https://doi.org/10.7577/formakademisk.3384

[13] Doenja Oogjes and Ron Wakkary. 2022. Weaving Stories: Toward Repertoires for Designing Things. *CHI Conference on Human Factors in Computing Systems*, ACM, 1–21. https://doi.org/10.1145/3491102.3501901

[14] Birger Sevaldson. 2018. Visualizing Complex Design: The Evolution of Gigamaps. In P. Jones and K. Kijima, eds., *Systemic Design*. Springer Japan, Tokyo, 243–269. https://www.doi.org/10.1007/978-4-431-55639-8_8

[15] Birger Sevaldson. 2019. What is Systemic Design? Practices Beyond Analyses and Modelling. In: Relating Systems Thinking and Design (RSD8) 2019 Symposium, Oct 13-15 2019, Chicago, USA. Available at http://openresearch.ocadu.ca/id/eprint/3233/

[16] M. Six Silberman, Lisa Nathan, Bran Knowles, *et al.* 2014. Next steps for sustainable HCI. *Interactions* 21, 5: 66–69. https://doi.org/10.1145/2651820

[17] Alex Taylor. 2015. After interaction. *Interactions* 22, 5: 48–53. https://doi.org/10.1145/2809888

[18] John Thackara. 2005. *In the bubble: Designing in a complex world*. MIT Press, Cambridge, Mass. https://doi.org/10.7551/mitpress/3702.001.0001

[19] Carlo Vezzoli and Ezio Manzini. 2008. *Design for Environmental Sustainability*. Springer London, London. https://www.doi.org/10.1007/978-1-84800-163-3

[20] Gian Wieck. 2021. Systems Mapping: How Paris meets Climate Change. *Systemic Design Group*. Retrieved March 31, 2022 from https://medium.com/systemic-design-group/systems-mapping-how-paris-meets-climate-change-664321d31f47.

[21] Ian Woodward. 2007. *Understanding Material Culture*. SAGE Publications Ltd, 1 Oliver's Yard, 55 City Road, London EC1Y 1SP United Kingdom. https://dx.doi.org/10.4135/9781446278987

[22] 2022. *L'effet rebond: une introduction*. Séminaire du groupe de travail Logiciel Éco-Responsable du GDR GPL (CNRS). Mediakiosque. https://mediakiosque.univ-pau.fr/video/12023-seminaire-du-dr-jacques-combaz-leffet-rebond-une-introduction-logiciel-eco-responsable-gt-du-gdr-gpl/

[23] Systemic Design Toolkit. Retrieved February 1, 2022 from https://www.systemicdesigntoolkit.org/.