Living Labs for Product Circularity: Learnings from the 'Innovation Network aiming at Sustainable Smartphones'

Conference Paper · September 2019

3 authors:

Ferdinand Revellio
Leuphana University Lüneburg

Erik G. Hansen
Johannes Kepler University Linz

Stefan Schaltegger
Leuphana University Lüneburg

Living Labs for Product Circularity: Learnings from the 'Innovation Network aiming at Sustainable Smartphones'

Revellio, Ferdinand [a,b]; Hansen, Erik G. [b,a]; Schaltegger, Stefan [a]
a) Centre for Sustainability Management (CSM), Leuphana University of Lüneburg, Germany
b) Institute for Integrated Quality Design (IQD), Johannes Kepler University (JKU) of Linz, Austria

Keywords: Circular Economy; Living Labs; Co-Creation; Consumer Electronics; Smartphones.

Abstract: Adopting the concept of a circular economy at a product level requires firms to rethink their business model and collaborate with partners across their value chain. Reaching product circularity through closing, slowing, and narrowing resource loops can be understood as a systems innovation, which calls for transdisciplinary research approaches. This paper presents insights from the 'Innovation Network aiming at Sustainable Smartphones' (INaS) located at the authors' institute. INaS is a living lab that brings together actors from the entire smartphone value chain to co-create circular product and service innovations. We contribute to research and practice with a process framework for leveraging partnerships through living labs for product circularity.

Introduction

Sustainability transitions require technical innovations, but also novel production, organisation and consumption patterns with implications for entire value chains. The circular economy (CE) provides a comprehensive framework to envision this transition with key concepts such as product-service systems and (collaborative) circular business models (Bocken, Olivetti, Cullen, Potting, & Lifset, 2017; Stahel, 1984). The CE thus requires a systemic transformation beyond a single product or organization to realize circular product and material flows. Given the complexity of this challenge, companies need to collaborate with external actors across a product's life-cycle (Krikke, Hofenk, & Wang, 2013).

We are interested in facilitating and researching early stage collaborative innovation processes, particularly how value chain actors can be brought together in order to embark towards circularity. Inspired by the transdisciplinary research paradigm for (corporate) sustainability science (Lang et al., 2012; Schaltegger, Beckmann, & Hansen, 2013) we take a transformative role through developing a platform for learning, sharing and collaborating with practitioners at eye level (Pereira, Karpouzoglou, Frantzeskaki, & Olsson, 2018). In this conference paper, we present initial insights from a living lab for product circularity as a "forum for innovation" (Voytenko, McCormick, Evans, & Schliwa, 2016) with a special focus on the smartphone industry.

Key concepts

Product circularity for consumer goods

The CE concept envisions circular flows for both, products of consumption (e.g. biodegradable tire abrasion) and products of use (e.g. smartphones) (Braungart, McDonough, & Bollinger, 2007; EMF, 2012). For the latter category, we refer to the concept of product circularity with three basic strategies of slowing, narrowing, and closing resource loops (Bocken, Pauw, Bakker, & van der Grinten, 2016; Stahel, 2010). These are based on the fundamental environmental strategies of eco-efficiency, sufficiency, and consistency respectively (Huber, 1995, 2000). Thereby strategies for slowing resource loops refer to each end-of-use phase and include practices like repairs, second-hand markets, refurbishing and upgrading. Narrowing strategies include eco-efficient product design and flows. The third strategy of closing loops applies to the end-of-life phase and aims at comprehensive material recycling. As for most technical consumer electronics major environmental impacts result from the production phase, product lifetime extension (i.a. cascading use-phases) generally is a valuable approach to improve product sustainability (Cooper & Gutowski, 2017).

Living labs

The CE concept can be understood as a systems innovation with implications for technological change, firms' business models, industrial infrastructure, and user behaviour (Geels, 2004). Transdisciplinary (TD) research approaches are proposed to guide systems innovations as they require tactic knowledge from various stakeholders (Schneidewind & Scheck, 2013). In TD research, academics and practitioners address real-world problems with societal relevance and high uncertainty, jointly formulate goals, processes and solutions, and pilot actions (Lang et al., 2012; Wittmayer & Schäpke, 2014). Various participatory approaches like open innovation, learning-action networks, living labs, and real-life experiments have been discussed as forums to generate sustainable futures (Schneidewind & Scheck, 2013).

Living labs originally emerged in user-centric research in the 1990s at MIT in urban areas and have since then been applied to the business context to facilitate solutions to environmental problems that require collaboration from various organizations and thus transcend firm boundaries (Liedtke, Baedeker, Hasselkuß, Rohn, & Grinewitschus, 2015). Previous participatory projects in the CE context focus on material recycling from a disciplinary perspective (e.g. engineering or natural science) (Sahamie, Stindt, & Nuss, 2013). Applying the living lab concept to the CE context is a novel approach to facilitate collaborative innovation environments and intervention spaces to co-create circular products and services with practitioners (Leminen, Westerlund, & Nyström, 2012).

Method

To analyse our collaborative setting we draw on a single longitudinal case study method (Yin, 2014) as it is considered particularly valuable to "unravel the underlying dynamics of a phenomenon that play out over time" (Siggelkow, 2007). In this article, we present insights from the 'Innovation Network aiming at Sustainable Smartphones' (INaS) over a period of three years (2016-2019). Given that we setup the living lab ourselves and coordinated the interventions, our case study developed in an action research context (Huxham & Vangen, 2003). As an embedded case with multiple units of analysis, we cover both the lab level (e.g. composition, process, interventions) and the level of individual actors (e.g. companies and their representatives). To evaluate and reflect our innovation lab we employ multiple data sources from different stages along the process (see Table 1), including questionnaires, participatory observations, and interviews with participants (Babbie, 2013). In our analysis we use an iterative approach to reflect on transdisciplinary research principles (Dubois & Gadde, 2002; Lang et al., 2012).

Data type	#	length	Documents
Interviews (formal/informal)	5/6	10,8h	Transcripts/ field notes
Participatory observation	4	32h	Workshop documentation
Questionnaires	4	--	Results report
Archival data	35	--	PDFs, internal documents

Table 1: Data sources and types

Industry context: Consumer electronics

Smartphones are one of the most iconic consumer products of our time but they are also an archetypical artefact for the linearity of our economy. We find the smartphone industry a particularly useful example to study product circularity for two key reasons. First, numerous sustainability challenges are associated with their global production and consumption systems, which makes them an archetypal example for complex sustainability problems (Kates, 2001; Lang et al., 2012). The societal diffusion of smartphones brings sustainability challenges such as short first use-cycles, resource intensity, and e-waste to the public awareness (Moran, McBain, Kanemoto, Lenzen, & Geschke, 2015; OECD, 2012; Suckling & Lee, 2015). Second, various sustainability pioneers are currently emerging in the field. They establish more sustainable practices such as take-back and refurbishing business models or modular design strategies, most of which can be associated with the CE concept (Schischke, Proske, Nissen, & Lang, 2016; Watson et al., 2017).

Innovation Network aiming at Sustainable Smartphones (INaS)

We have set-up the INaS as a living lab to facilitate collaboration of various actors from the entire smartphone value chain and to research inter-organizational collaboration. In this way we aim to address sustainability challenges in the industry and co-create circular product and service innovations. With the INaS we aim to develop an open innovation space outside boundaries of individual firms to facilitate technological and societal innovations. In setting up the innovation lab, we have followed the transition management framework by Loorbach (2010) with consecutive strategic, tactical, operational, and reflexive activities. The following sections provide an overview of these activities.

Participants

We selected participating organizations from the entire smartphones' (circular) value chain, including suppliers, manufacturers, distributors, circular services providers (e.g. repair shops), and end-of-life facilities (e.g. recyclers). Each of these industry players links into circular value creation architectures via make, ally, buy, or laissez-faire relationships (Revellio & Hansen, 2017). Additionally, the network includes industry associations, societal practitioners, and universities as facilitators for knowledge transfer and absorption (Bishop, D'Este, & Neely, 2011). In total 22 organisations are currently members of the INaS. Figure 1 presents an overview of participants as of March 2018.

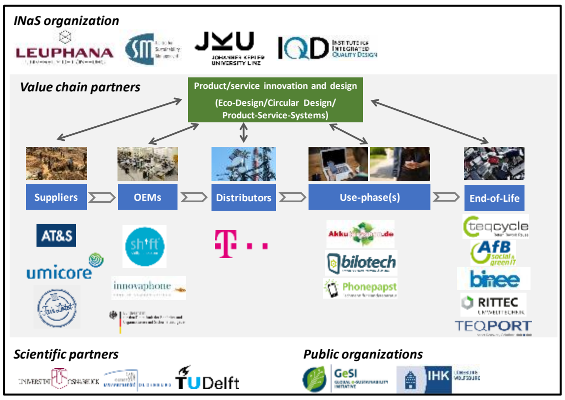

Figure 1. INaS participants 2016-2019, adapted from CSM (2018).

Lab vision through backcasting

To gear towards the desired future state of circular product and material flows we applied a backcasting approach. Backcasting was originally developed by Robinson (1990) and is since then successfully established to life-cycle management as a strategic planning tool for the management of product and material flows (Ny, MacDonald, Broman, Yamamoto, & Robért, 2006). This approach supported our exploratory and collaborative research design by providing direction and scope to the complex CE context (Mendoza, Sharmina, Gallego-Schmid, Heyes, & Azapagic, 2017). We termed our joint circular vision 'the service point of the future'. At this potential future customer interface, users could access circular products and services at a single point of contact to reduce transaction costs. Based on this vision we identified various circular challenges to jointly develop appropriate solutions with INaS participants and to achieve the desired future state of product circularity.

Facilitation processes and workshops

We have met with INaS participants regularly to jointly define challenges, co-develop ideas, and create low-resolution prototypes of circular products and services. Over a timeframe of two years (2016-2017), we conducted four consecutive full-day workshops (i.e. one workshop every 6 months). We covered both product and service innovation approaches with foci on product design, supply chains, product-service systems, and circular business models (Table 2). While this paper focuses on these completed, self-contained workshop series, it should also be noted that the lab has evolved into a second phase, with a new wave of workshops on modular product designs and complementary circular business models currently being prepared.

No.	Workshop topics	Duration
1	Sustainable product design and supply chains	8h
2	Product-service systems as sustainable consumption systems	7,5h
3	Devices as material banks. How to keep devices for value creation	8h
4	Value creation architectures and business models for the "Service Point of the Future"	7,5h

Table 2: INaS workshop overview

Each thematic workshop comprised both a "learning" element and an "action" element (Clarke & Roome, 1999). Learning elements consisted of academic and practitioner inputs on CE and sustainability topics to provide state of the art knowledge and best practices. For the action sessions, we applied user-centric design methods inspired by design-thinking techniques to bring knowledge into action. Following the learning sessions, small groups of 5-8 participants developed tangible prototypes for circular solutions, which then functioned as boundary spanning objects for reintegration in participants' organisations.

Exemplary workshop

We focus on the final “integration” workshop on (circular) business models (BMs) as an exemplar for our facilitation approach. The aim of the workshop was to support the implementation and commercialization of circular practices identified throughout the lab in the participants’ organisations by developing viable BMs. In an introductory session, we raised awareness and provided basic knowledge through interactive key-notes from BM experts. In the following co-creation session, we used an adapted version of the business innovation kit (Breuer & Lüdeke-Freund, 2018), a business game for developing sustainability-oriented business models. To facilitate solutions based on the previous workshops we developed a proprietary extension with special facilitation cards for each BM element (see Figure 2 for an exemplary card). These facilitaion cards consist of three components. The top part contains guiding questions for the corresponding BM element extended with CE specific features. The middle part contains previously developed solutions from INaS participants in prior thematic workshops. The bottom part contains a slection of related market data. Facilitated by one of the developers of the business model kit, participants co-developed collaborative business models for product circularity. In a third session, we integrated and discussed the results from each individual group to find complementarities. Exemplary BMs included platforms for third-party repair centres (for details see Hansen, Revellio, Schaltegger, Zufall, & Norris, 2018).

Exemplary innovation outcomes at participants’ organisations

Practical outcomes from the innovation lab include product, process, and organizational innovations. *Product innovations* developed especially in the field of services. They include full-service offers for B2B customers focused on life-cycle management. An exemplary implemented *process innovation* is a proprietary deposit system for smartphones implemented by one of the participating OEMs to increase return rates for their own devices and to develop a closed-loop system for products, parts and selected materials. *Organisational innovations* include a number of partnerships between participating firms. For

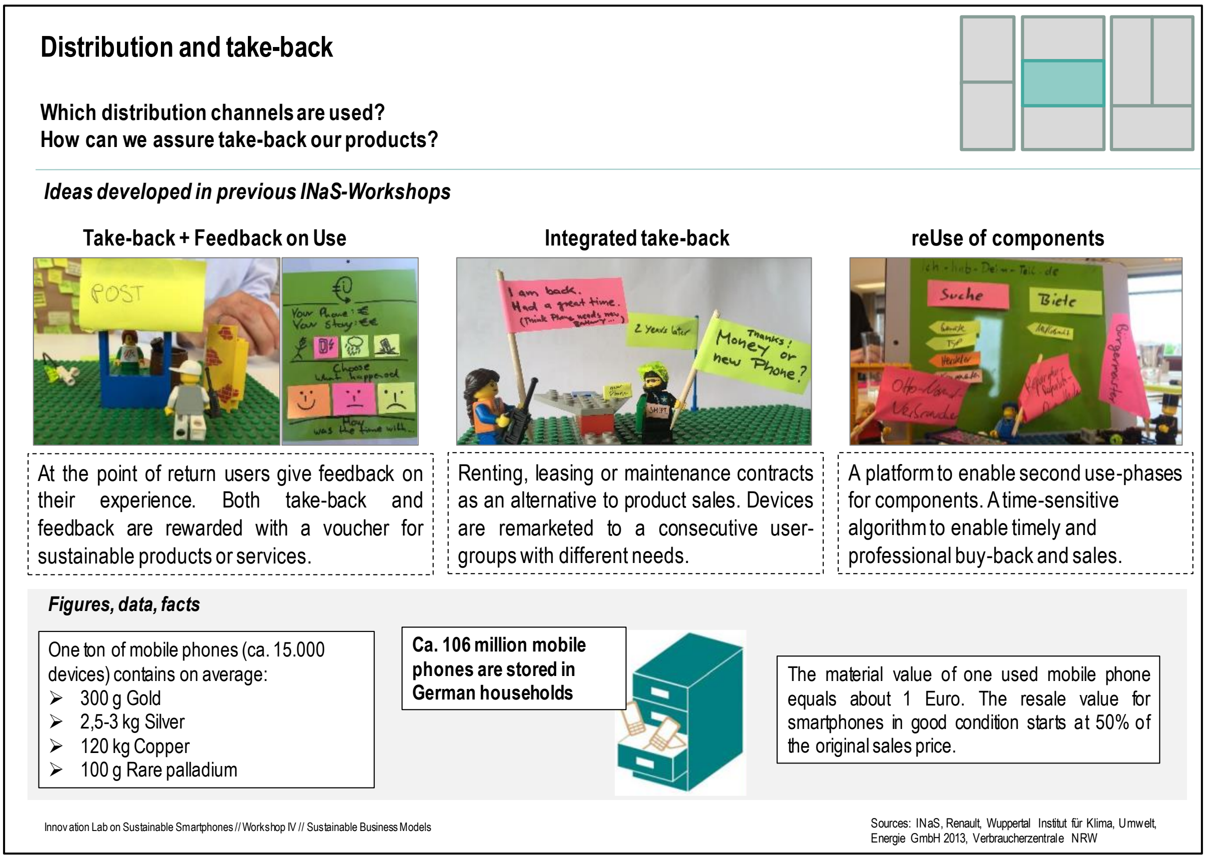

Figure 2: Exemplary facilitation card for the fourth workshops on circular business models. © CSM 2017

example, an e-waste collection firm now collaborates with a repair firm to exchange harvested spare parts.

Additionally, a number of intangible and indirect outcomes emerged that cannot directly be traced to the INaS activities. These include loose collaborations between partners, inspiration for adapted product designs, and impacts on corporate strategies.

Discussion

We have developed a process framework for circular living labs to facilitate product circularity across the life-cycle (see Figure 3). The framework contains the basic planning elements of actors, processes and outcomes.

Through consecutive thematic workshops and participatory co-creation sessions at the impartial location of a university, we have created and maintained a "transformation space" for corporate actors to envision circular solutions. This "safe enough" environment of our lab proved to be an important feature appreciated by corporate actors, as it enabled experimentation with new mental models outside of the conventional linear solutions space (Pereira et al., 2018). As a result, participants developed both exploratory and exploitative capabilities (Bishop et al., 2011). Participants acquired exploratory knowledge and improved their fundamental understanding for the CE during the workshops and prototyping sessions. An example of exploitative learning is the commercially realized deposit system for smartphones by one of the participants that also influenced their overall CE strategy.

We find that the CE concept is a suitable framework for a relatively comprehensive perspective on (environmental) sustainability in the consumer electronics industry. It can not only spur sustainability-oriented innovation and collective learning processes across all phases of a smartphone's life-cycle, but also across technological and non-technological (service) domains (Hansen, Große-Dunker, & Reichwald, 2009).

Reflection

Our roles as researchers in the project changed over time (Wittmayer & Schäpke, 2014). During the workshops series we took knowledge broker and process facilitator roles. Overtime, our role developed into a continuous relationship facilitator and change agent while continuously assisting partners inside and actors outside the network in the development of new products, services, and partnerships in the industry. This confirms that innovation labs flourish through active management and continuous communication (Kirschten, 2006). Furthermore, we used outcomes and

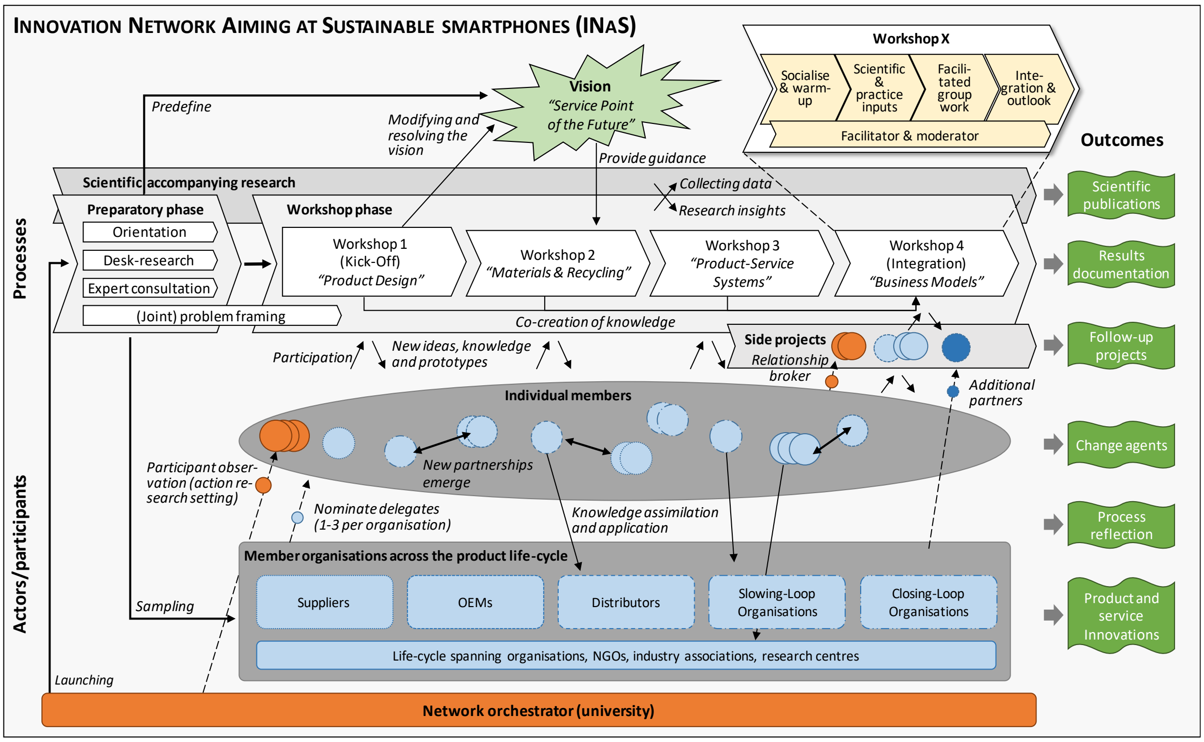

Figure 3: INaS process framework for living labs facilitating product circularity

observations from the innovation lab in our role as reflective researchers to analyse implications for the circular economy on a more abstract level.
With the lab located in Europe, we did not succeed in reaching the desired representation of the smartphone's production system primarily located in Asia and therefore miss the direct impact on mainstream product designs. However, the coverage of entrepreneurial niche actors from the European production and consumption system turned out to be a valuable advantage, as it enabled fast implementation of pioneering approaches. Moreover, independent from product design changes, it allows to more deeply explore slowing loops strategies for consumer electronics in the use-phase. This also demonstrates the CE concept's potential for regional job creation (EC, 2015; Stahel & Reday-Mulvey, 1976).

Conclusion

We find that innovation labs for product circularity benefit from value chain spanning compilation of actors, transdisciplinary and participatory approaches, prototyping sessions, and follow-up bilateral side projects. In this way, INaS was established as an (national) incubator for product circularity in the consumer electronics industry. Our work contributes to the existing literature at the intersection of the CE, innovation, and living labs with a process framework for leveraging co-creation of product circular in transdisciplinary settings. Practical implications of our research involve improved process knowledge for leveraging partnerships to innovate and commercialize circular offers as well as policy implications for supporting circularity.

Acknowledgments

We would like to thank all INaS participants for their collaboration. The project was funded as part of the larger research project "eCoInnovateIT" ["Nachhaltiger Konsum von Informations- und Kommunikations-technologie in der digitalen Gesellschaft – Dialog und Transformation durch offene Innovation"], project no. VWZN3037, with additional contributions from the Institute for Integrated Quality Design (IQD), which is jointly funded by Quality Austria (Quality Austria - Trainings, Zertifizierungs und Begutachtungs GmbH, Vienna), the State of Upper Austria and Johannes Kepler University (JKU) Linz.

References

Babbie, E. R. (2013). *The practice of social research* (13. ed., internat. ed.). Belmont Calif. u.a.: Wadsworth Cengage Learning.

Bishop, K., D'Este, P., & Neely, A. (2011). Gaining from interactions with universities: Multiple methods for nurturing absorptive capacity. *Research Policy*, *40*(1), 30–40. https://doi.org/10.1016/j.respol.2010.09.009

Bocken, N. M. P., Olivetti, E. A., Cullen, J. M., Potting, J., & Lifset, R. (2017). Taking the Circularity to the Next Level: A Special Issue on the Circular Economy. *Journal of Industrial Ecology*, *21*(3), 476–482. https://doi.org/10.1111/jiec.12606

Bocken, N. M. P., Pauw, I. de, Bakker, C. A., & van der Grinten, B. (2016). Product Design and Business Model Strategies for a Circular Economy. *Journal of Industrial and Production Engineering*, *33*(5), 308–320. https://doi.org/10.1080/21681015.2016.1172124

Braungart, M., McDonough, W., & Bollinger, A. (2007). Cradle-to-Cradle Design: Creating Healthy Emissions – A Strategy for Eco-Effective Product and System Design. *Journal of Cleaner Production*, *15*(13-14), 1337–1348. https://doi.org/10.1016/j.jclepro.2006.08.003

Breuer, H., & Lüdeke-Freund, F. (2018). Values-Based Business Model Innovation: A Toolkit. In L. Moratis, F. Melissen, & S. O. Idowu (Eds.), *Sustainable Business Models: Principles, Promise, and Practice* (Vol. 43, pp. 395–416). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-73503-0_18

Centre for Sustainability Management (2018). Innovationsverbund Nachhaltige Smartphones: Partner. Retrieved from https://www.leuphana.de/institute/csm/forschung-projekte/inas/partner.html

Clarke, S. F., & Roome, N. J. (1999). Sustainable business: Learning - action networks as organizational assets. *Business Strategy and the Environment*, *8*(5), 296–310. https://doi.org/10.1002/(SICI)1099-0836(199909/10)8:5

Cooper, D. R., & Gutowski, T. G. (2017). The Environmental Impacts of Reuse: A Review. *Journal of Industrial Ecology*, *21*(1), 38–56. https://doi.org/10.1111/jiec.12388

Dubois, A., & Gadde, L.-E. (2002). Systematic Combining: An Abductive Approach to Case Research. *Journal of Business Research*, *55*(7), 553–560. https://doi.org/10.1016/S0148-2963(00)00195-8

Ellen MacArthur Foundation (EMF) (2012). *Towards the Circular Economy 1: Economic and Business Rationale for an Accelerated Transition* (No. 1). Retrieved from EMF website: www.ellenmacarthurfoundation.org/assets/downloads/publications/ellen-Macarthur-foundation-towards-the-circular-economy-vol.1.pdf

European Commission (EC) (2015). *Closing the loop: An EU action plan for the Circular Economy*.

Brussels. Retrieved from EC website: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52015DC0614

Geels, F. W. (2004). Understanding system innovations: A critical literature review and a conceptual synthesis. In B. Elzen, F. W. Geels, & K. Green (Eds.), *System innovation and the transition to sustainability: Theory, evidence and policy* (pp. 19–47). Cheltenham: Elgar.

Hansen, E. G., Große-Dunker, F., & Reichwald, R. (2009). Sustainability Innovation Cube: A Framework to Evaluate Sustainability-Oriented Innovations. *International Journal of Innovation Management*, *13*(4), 683–713.

Hansen, E. G., Revellio, F., Schaltegger, S., Zufall, J., & Norris, S. (2018). *Innovationsverbund Nachhaltige Smartphones (INaS): Workshop IV - Wertschöpfungs-architekturen und Geschäftsmodelle für den «Service Point of the Future»* (Ergebnisdokumentation). Lüneburg, Germany.

Huber, J. (1995). *Nachhaltige Entwicklung: Strategien für eine ökologische und soziale Erdpolitik*. Berlin: Ed. Sigma.

Huber, J. (2000). Towards industrial ecology: sustainable development as a concept of ecological modernization. *Journal of Environmental Policy and Planning*, *2*(4), 269–285. https://doi.org/10.1080/714038561

Huxham, C., & Vangen, S. (2003). Researching Organizational Practice through Action Research: Case Studies and Design Choices. *Organizational Research Methods*, *6*(3), 383–403. https://doi.org/10.1177/1094428103254454

Kates, R. W. (2001). Sustainability Science. *Policy Forum: Environment and Development*. (292), 641–642. Retrieved from http://www.jstor.org/stable/3083523

Kirschten, U. (2006). Nachhaltige Innovationsnetzwerke in Theorie und Praxis: Ausgewählte Forschungsergebnisse. In R. Pfriem (Ed.), *Wirtschaftswissenschaft. Innovationen für eine nachhaltige Entwicklung: [jährliche Herbsttagung der Kommission Umweltwirtschaft des Verbandes der Hochschullehrer für Betriebswirtschaftslehre]* (1st ed., pp. 269–286). Wiesbaden: Deutscher Universitäts-Verlag. https://doi.org/10.1007/978-3-8350-9332-4_13

Krikke, H., Hofenk, D., & Wang, Y. (2013). Revealing an invisible giant: A comprehensive survey into return practices within original (closed-loop) supply chains. *Resources, Conservation and Recycling*, *73*, 239–250. https://doi.org/10.1016/j.resconrec.2013.02.009

Lang, D. J., Wiek, A., Bergmann, M., Stauffacher, M., Martens, P., Moll, P., . . . Thomas, C. J. (2012). Transdisciplinary Research in Sustainability Science: Practice, Principles, and Challenges. *Sustainability Science*, *7*(S1), 25–43. https://doi.org/10.1007/s11625-011-0149-x

Leminen, S., Westerlund, M., & Nyström, A.-G. (2012). Living Labs as Open-Innovation Networks. *Technology Innovation Management Review*, *2*(9), 6–11. https://doi.org/10.22215/timreview/602

Liedtke, C., Baedeker, C., Hasselkuß, M., Rohn, H., & Grinewitschus, V. (2015). User-integrated innovation in Sustainable LivingLabs: an experimental infrastructure for researching and developing sustainable product service systems. *Journal of Cleaner Production*, *97*, 106–116. https://doi.org/10.1016/j.jclepro.2014.04.070

Loorbach, D. (2010). Transition Management for Sustainable Development: A Prescriptive, Complexity-Based Governance Framework. *Governance*, *23*(1), 161–183. https://doi.org/10.1111/j.1468-0491.2009.01471.x

Mendoza, J. M. F., Sharmina, M., Gallego-Schmid, A., Heyes, G., & Azapagic, A. (2017). Integrating Backcasting and Eco-Design for the Circular Economy: The BECE Framework. *Journal of Industrial Ecology*, *21*(3), 526–544. https://doi.org/10.1111/jiec.12590

Moran, D., McBain, D., Kanemoto, K., Lenzen, M., & Geschke, A. (2015). Global Supply Chains of Coltan. *Journal of Industrial Ecology*, *19*(3), 357–365. https://doi.org/10.1111/jiec.12206

Ny, H., MacDonald, J. P., Broman, G. I., Yamamoto, R., & Robért, K.-H. (2006). Sustainability Constraints as System Boundaries: An Approach to Making Life-Cycle Management Strategic. *Journal of Industrial Ecology*, *10*(1-2), 61–77. https://doi.org/10.1162/108819806775545349

Organisation for Economic Cooperation and Development (2012). *Case Study on Critical Metals in Mobile Phones: Final Report*. Retrieved from Organisation for Economic Cooperation and Development (OECD) website: http://www.oecd.org/env/waste/Case Study on Critical Metals in Mobile Phones.pdf

Pereira, L. M., Karpouzoglou, T., Frantzeskaki, N., & Olsson, P. (2018). Designing transformative spaces for sustainability in social-ecological systems. *Ecology and Society*, *23*(4). https://doi.org/10.5751/ES-10607-230432

Revellio, F., & Hansen, E. G. (2017). *Value Creation Architectures for the Circular Economy: A Make-or-Buy Analysis in the Smartphone Industry* (Working Paper). Lüneburg, Germany. Retrieved from Centre for Sustainability Management (CSM), Leuphana University of Lüneburg. website: https://www.researchgate.net/publication/324727193_Value_Creation_Architectures_for_the_Circular_Economy_A_Make-or-Buy_Analysis_in_the_Smartphone_Industry

Robinson, J. B. (1990). Futures under glass: A recipe for people who hate to predict. *Futures*, *22*(8), 820–842. https://doi.org/10.1016/0016-3287(90)90018-D

Sahamie, R., Stindt, D., & Nuss, C. (2013). Transdisciplinary Research in Sustainable Operations - An Application to Closed-Loop Supply Chains. *Business Strategy and the Environment*, *22*(4), 245–268. https://doi.org/10.1002/bse.1771

Schaltegger, S., Beckmann, M., & Hansen, E. G. (2013). Transdisciplinarity in Corporate Sustainability: Mapping the Field. *Business Strategy and the Environment*, *22*(4), 219–229. https://doi.org/10.1002/bse.1772

Schischke, K., Proske, M., Nissen, N. F., & Lang, K.-D. (2016). Modular products: Smartphone design from a circular economy perspective. In *2016 Electronics Goes Green 2016+ (EGG)* (pp. 1–8). IEEE. https://doi.org/10.1109/EGG.2016.7829810

Schneidewind, U., & Scheck, H. (2013). Die Stadt als „Reallabor" für Systeminnovationen. In J. Rückert-John (Ed.), *Research. Soziale Innovation und Nachhaltigkeit: Perspektiven sozialen Wandels* (pp. 229–248). Wiesbaden: Springer VS. https://doi.org/10.1007/978-3-531-18974-1_12

Siggelkow, N. (2007). Persuasion With Case Studies. *Academy of Management Journal*, *50*(1), 20–24. https://doi.org/10.5465/amj.2007.24160882

Stahel, W. R. (1984). The Product Life Factor. In S. G. Orr (Ed.), *An Inquiry into the Nature of Sustainable Societies:: The Role of the Private Sector* (pp. 72–104).

Stahel, W. R. (2010). *The Performance Economy* (2nd ed.). Basingstoke, England, New York: Palgrave Macmillan.

Stahel, W. R., & Reday-Mulvey, G. (1976). *Jobs for Tomorrow: The Potential for Substituting Manpower for Energy*. Report to the Commission of the European Communities. Brussels, New York: Vantage Press.

Suckling, J. R., & Lee, J. (2015). Redefining Scope: The True Environmental Impact of Smartphones? *The International Journal of Life Cycle Assessment*, *20*(8), 1181–1196. https://doi.org/10.1007/s11367-015-0909-4

Voytenko, Y., McCormick, K., Evans, J., & Schliwa, G. (2016). Urban living labs for sustainability and low carbon cities in Europe: towards a research agenda. *Journal of Cleaner Production*, *123*, 45–54. https://doi.org/10.1016/j.jclepro.2015.08.053

Watson, D., Tojo, N., Bauer, B., Milios, L., Gylling, A. C., & Throne-Holst, H. (2017). *Circular Business Models in the Mobile Phone Industry*. *TemaNord*. Copenhagen: Nordic Council of Ministers. Retrieved from http://dx.doi.org/10.6027/tn2017-560

Wittmayer, J. M., & Schäpke, N. (2014). Action, research and participation: roles of researchers in sustainability transitions. *Sustainability Science*, *9*(4), 483–496. https://doi.org/10.1007/s11625-014-0258-4

Yin, R. K. (2014). *Case Study Research: Design and Methods* (5th ed.). *Applied social research methods series: Vol. 5*. Los Angeles, Calif.: SAGE Publ.