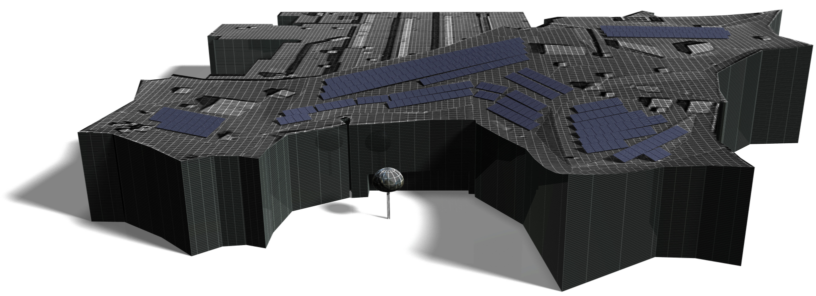
Design

Design against Reverse Salients

Strategic design for the short-term future for sustainability transitions

Luisa Mok



Aalto University

DOCTORAL DISSERTATIONS

Aalto University publication series
DOCTORAL DISSERTATIONS 166/2019

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Aalto University publication series
DOCTORAL DISSERTATIONS 166/2019

ISBN 978-952-60-8716-0 (printed)
ISBN 978-952-60-8717-7 (pdf)
ISSN 1799-4934 (printed)
ISSN 1799-4942 (pdf)
http://urn.fi/URN:ISBN:978-952-60-8717-7

Images: Cover image: Dipoli, Espoo, Finland. Architectural visualisation by Luisa Mok

Unigrafia Oy
Helsinki 2019

Finland

Publication orders (printed book):
books.aalto.fi
artsbooks@aalto.fi

NORDIC SWAN ECOLABEL
Printed matter
4041-0619

A? Aalto University

Aalto University, P.O. Box 11000, FI-00076 Aalto www.aalto.fi

Abstract

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Name of the doctoral dissertation
Design against Reverse Salients

Publisher School of Arts, Design and Architecture

Unit Design

Series Aalto University publication series DOCTORAL DISSERTATIONS 166/2019

Field of research Design research

Date of the defence 30 October 2019

Language English

☒ **Monograph** ☐ **Article dissertation** ☐ **Essay dissertation**

Abstract

Design solutions for sustainability are easily restrained from producing their intended outcomes. One key reason given to explain design shortfalls is that designers do not recognise the critical phenomena of systems transitions emerging in the near future. In view of the difficulty of achieving sustainability transitions, I am compelled to think about what design can do to realise sustainable futures.

Reverse salients, the term conceptualises problems inherent in the near future, which may lead to disastrous consequences that eventually impede overall systems transitions. They are problems that are not seen at the present; even if they are projected, they are not easy to solve. These obstacles to sustainability transitions in the near future have to be anticipated and progressively overcome in order to further the transitions process before they lead to future critical adverse situations that hamper overall systems transitions. This implies design for sustainability cannot be limited to merely generating long-term visions that may lack operational effectiveness in the short-term or to only solving present problems without strategic importance. Focusing on the short-term future posits an alternative design approach.

Through integrating transitions theories and strategic design studies, this dissertation develops a new design approach, namely Strategic Design for the Short-term Future, which has the present-day importance of the short-term issues. The research contributes to a new research area of exploring an alternative strategic design with anticipatory strength as well as operational effectiveness in order to pre-empt future adverse results. To build theory for guiding design practice, two case studies are conducted in this dissertation providing extensive empirical evidences. The two transitions cases deliberately chosen for theory investigation concern renewable energy transitions applied to advancing the use of solar photovoltaic panels on a heritage building called Dipoli in Finland and sustainable aquaculture transitions applied to Finnish sustainable salmon trout aquaculture in the Baltic Sea. The research results demonstrate two short-term future visions that connect longer-term goals and the present-day actions to solve problems arising in future situations.

Consequently, the new strategic design enables designers to anticipate and overcome problems arising in the short-term future – that is, design against reverse salients.

Keywords Design for sustainability, Reverse salients, Short-term future, Transition(s) design, Sustainability transitions, Strategic design

ISBN (printed) 978-952-60-8716-0 **ISBN (pdf)** 978-952-60-8717-7

ISSN (printed) 1799-4934 **ISSN (pdf)** 1799-4942

Location of publisher Helsinki **Location of printing** Helsinki **Year** 2019

Pages 200 **urn** http://urn.fi/URN:ISBN:978-952-60-8717-7

Aalto-yliopisto

Aalto-yliopisto, PL 11000, 00076 Aalto www.aalto.fi

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Julkaisija Taiteiden ja suunnittelun korkeakoulu

Yksikkö Name of the Department

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Tutkimusala Malesuada vel massa

Väitöspäivä 30.10.2019

Kieli Englanti

☒ **Monografia** ☐ **Artikkeliväitöskirja** ☐ **Esseeväitöskirja**

Tiivistelmä

Avainsanat

ISBN (painettu) 978-952-60-8716-0 **ISBN (pdf)** 978-952-60-8717-7

ISSN (painettu) 1799-4934 **ISSN (pdf)** 1799-4942

Julkaisupaikka Helsinki **Painopaikka** Helsinki **Vuosi** 2019

Sivumäärä 200 **urn** http://urn.fi/URN:ISBN:978-952-60-8717-7

Design against Reverse Salients: strategic design for the short-term future for sustainability transitions

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Contents

Foreword

The Low2No project of the Helsinki Design Lab (HDL), which ran between 2008 and 2013 in Helsinki, Finland, was a design initiative sponsored by Sitra. Sitra is a Finnish innovation fund that operates under the supervision of the Finnish Parliament. Low2No was a large-scale design project. It aimed at radically transitioning Helsinki towards a sustainable future, from low-carbon to no-carbon urban construction, through strategic design of carbon-neutral architecture (Helsinki Design Lab, 2014). The strategy of this architecture project was to utilise optimised design to achieve its long-term sustainable visions (Bechthold and Kane, 2011; Hill, 2012; Steinberg, 2015). However, the project was eventually terminated when Sitra divested itself of the project in 2012, which in consequence prompted the withdrawal of major collaborating construction companies from the project (Helsinki Design Lab, 2013; Steinberg, 2015).

The failure of this design project for sustainability made me think of the constraints on sustainability transitions. I interviewed the Director of Strategic Design, hoping to find out why the project failed. In hindsight, the Director of Strategic Design of Low2No explained that they did not foresee the withdrawal of the incumbent construction companies that resisted the changes. In this project, the incumbents were interconnected with major and supporting industries and the established Finnish construction market as well as social and economic infrastructures. The Director postulated that this hampered the national sustainable agenda of transforming Helsinki into a sustainable city (Steinberg, 2015).

At this point, I pondered whether the withdrawal of the construction companies could have been foreseen. If an eventuality such as this is foreseen, can we use design to intervene at an opportune time to mitigate the issue before it leads to the failure of the whole project and other adverse results? This implied that a deliberate intervention to mitigate problems that might arise in the near future is needed. However, the opportunity to use design to create carbon-neutral architecture to make Helsinki a sustainable city has finally faded. If sustainability transitions are so tough to achieve, what room is there for design to realise sustainable futures? In view of the difficulty of achieving sustainability transitions from Low2No, I am compelled to think about what design can do to realise sustainable futures.

To succeed in solving these complex, unforeseen problems from the field of design clearly requires comprehensive design methods. While to develop the methods demands systematic inquiry to build theories for application. Connecting design practice to academic design has been my belief for being able to practically solve problems in the real world. In this sense, producing design knowledge through methodological inquiry to support application has formed the concept of this design research. This frames my work as a practice-relevant design research for guiding design practice for sustainability in the real world.

The project serves as an example of design for sustainability transitions in the broader systems context. This design project for sustainability transitions showed that a lack of understanding about the complexity of sustainability transitions would have led to a failure to capitalise on a design opportunity to facilitate transitions for sustainability. To avoid similar failures as Low2No in the future, logically, two suppositions have come out. First, when design takes up systemic challenges for sustainability transitions, there must be sufficient theories for design to comprehend the high complexity of systems transitions. Second, a strategic design focusing on the critical phenomena of sustainability transitions implicating problems in the near future should be developed. My research started with aim of realising these two suppositions.

Abstract

Design solutions for sustainability are easily restrained from producing their intended outcomes. One key reason given to explain design shortfalls is that designers do not recognise the critical phenomena of systems transitions emerging in the near future.

Reverse salients, the term conceptualises problems inherent in the near future that would cause future adverse outcomes. They are problems that are not seen at the present; even if they are projected, they are not easy to solve. These obstacles to sustainability transitions in the near future have to be anticipated and progressively overcome in order to further the transitions process before they lead to critical situations that hamper overall systems transitions. Failure to recognise problems in the short-term future would prevent design for sustainability from achieving its objectives. In the recent decade, design for sustainability research on socio-technical systems has developed a systems perspective for large-scale sustainability transitions and expanded design knowledge through integration with other fields of knowledge. They have laid an important foundation in design for sustainability research at the systems level. However, approaches targeting transitions challenges concerning problems emerging in the near future are found to be underexplored in current research. Design for sustainability cannot be limited to merely generating long-term visions that may lack operational effectiveness in the short-term or to only solving present problems without strategic importance. The urge to fulfil the research need focusing on the midway posits an alternative design approach for the short-term future. Furthermore, the concept of reverse salients has not been adopted by design research, but has relevance in the development of design for sustainability that facilitates the reorientation of transitions pathways. This motivates research to learn to anticipate and overcome obstacles to sustainability transitions in the short-term future by adopting the concept of reverse salients.

Setting the research aim to deal with problems emerging in the short-term future in systems transitions, three research questions are formulated as follows,

1. Which are the critical phenomena of systems transitions that prevent design for sustainability from achieving its objectives?

2. How can design for sustainability identify and solve problems that are emerging in the short-term future?
3. What form of guidance can be provided for designers to meet the short-term future challenges in sustainability transitions?

To learn to encounter transitions obstacles in the short-term future, transitions theories and strategic design studies are adopted and integrated to explore a new design approach. The theoretical understanding attained from the two fields of studies offers insights into anticipating problems emerging in the short term and developing short-term future planning. To develop the theoretical insights, case study is used as the research method in this research. The two transitions cases deliberately chosen for theory investigation concern renewable energy transitions applied to advancing the use of solar photovoltaic panels on a heritage building called Dipoli in Finland and sustainable aquaculture transitions applied to Finnish sustainable salmon trout aquaculture in the Baltic Sea. The future challenge in the renewable energy case is posed by the architectural experts' recommendations regarding the siting of solar PV on the heritage rooftop, which may lead to the categorical rejection of installing solar PV panels on Dipoli and furthermore across all heritage buildings. The future challenge in the sustainable aquaculture transitions case comes from the fish farmers' aspiration to attain international accreditation for salmon trout aquaculture in the Baltic Sea, which may, however, result in a failure to grow offshore salmon trout aquaculture and furthermore have an adverse impact on overall Finnish sustainable aquaculture transitions. Both cases indicate the critical phenomena of systems transitions that urge a deliberate intervention to reorient transitions. To further the transition process by addressing near-future transitions challenges, the two cases demonstrate two short-term future visions that connect longer-term goals and the present-day actions to solve problems arising in future situations. In other words, these future visions are strategic, as they place operational importance on strategic design to solve foreseeably forming reverse salients. In the research, the two case studies explore how exactly problems in the short-term future are identified and overcome, thereby providing extensive empirical evidences to develop theoretical insights to formulate a genuine design process to meet short-term future challenges.

Analysing the two cases through a systematic and logical case study analytic process develops a new design approach that is explained in a design process model, namely Strategic Design for the Short-term Future. The new design model serves to guide the design process to create strategic design solutions for short-term future planning with a focus of mitigating reverse salients arising in transitions. The resulting design model is theoretically underpinned to sufficiently explain the phenomena of ongoing transitions situations as well as comprehend problems inherent in the near future. In addition, the design model is empirically valid to confirm that the design approach is adequate to guide the design process to create short-term future planning for the identified problems. Adopting the concept of reverse salients has yielded the

key attributes of the new design model. The attributes, on the one hand, define the anticipatory role of the new model in the short-term future to identify reverse salients. On the other, they also determine the operational importance of the model to practically mitigate reverse salients. These form the unique quality of the new design model that has the present-day importance of the short-term issues.

This research result contributes to the current research with a focus on encountering sustainability transitions obstacles in the short-term future to further the transitions process, which makes its practical and theoretical values. Regarding practical contribution, a new design process model – Strategic Design for the Short-term Future – is developed to guide design practice. To achieve the guiding purpose, the new model organises a clearly defined six-stage design process to practically guide design in the real world for sustainability transitions. Considering theoretical contribution, the concept of reverse salients is newly applied to design research but has significance relevance for new strategic design for sustainability. The concept offers a conceptual understanding of the emergent transitions challenges in the short-term future, which informs an alternative design approach to reorient transitions towards achieving sustainable futures,

This design research builds theory to support application for design practice. The design research concept connects design practice and academic research to practically solve problems in the real world. Consequently, this research has suggested an alternative design approach to a different transitions challenge. The new approach enables designers to address the critical phenomena of systems transitions emerging in the short-term future – that is, design against reverse salients.

Keywords:
Design for sustainability, Reverse salients, Short-term future, Transition(s) design, Sustainability transitions, Strategic design

Abbreviations

AVI	The Regional State Administrative Agency for Southern Finland
ASC	Aquaculture Stewardship Council
LUKE	The Natural Resources Institute Finland
HDL	Helsinki Design Lab
MLP	Multilevel perspective
PV	Photovoltaic
STS	Science and technology studies
VSD	Value Sensitive Design
WWF	The World Wildlife Fund

List of figures and tables

Acknowledgements

After a fulfilling and rewarding career as an industrial designer, I wanted to pursue a more satisfying answer to the contribution of design for sustainability to society. The pursuit of this idea brought me to Finland in 2014. This decision to put aside my industrial design work in the middle of my career required substantial courage. I wish to acknowledge my deep gratitude to a few people for their encouragement, guidance and support during my doctoral journey.

I would like to first express my gratitude to my advisors, Professor Jack Whalen, for his valuable suggestions during the planning of my research and Professor Idil Gaziulusoy for the advice, support and enthusiastic encouragement she gave to me over many months. In addition, I want to extend my sincere thanks to Professor Sampsa Hyysalo, who introduced me to the concept of reverse salients, which has built the most important cornerstone of my research. I must also express my deepest gratitude and appreciation to my supervisor, Professor Turkka Keinonen, for his guidance and motivation to me in the critical last phase of my dissertation. There are two other professors I have pestered with questions in school and now I want to express my appreciation to them: Professor Oscar Person, who answered my questions about what exactly strategic design is, and Professor Pekka Korvenmaa, who shared countless stories about Finnish design, which in turn gave me creative inspiration in my writing. Additionally, I want to thank Dr. Luke Feast for all his illuminating discussions with me, covering topics ranging from research perspective to the complexities of design approaches. My thanks to two research groups, the Users and Innovation Research Group INUSE and the Sustainable Design Research Group NODUS, for embracing me as their family member regardless of my minor contribution. The financial support offered by the Department of Design as a doctoral candidate in design research is also acknowledged with appreciation.

There are many people to whom I wish to express my indebtedness for their help, assistance and support. They include Jenni Väänänen and Namkyu Chun for the team work in exploring Dipoli, particularly climbing up and down the rooftop; Kristo Vesikansa for offering his heritage preservation insights; and Jari Setälä, Markus Kankainen, Raija Aaltonen, Ville Salonen and Timo Halonen for sharing with me their expert knowledge in Finnish sustainable aquaculture. I am also deeply grateful to Marco Steinberg for sharing with me his vision of utilising a large-scale architecture project to achieve a sustainable future. There are more people I should thank, but cannot mention here due to the limited space available – thank you. Additionally, I thank Joel Kuntonen for giving his professional suggestions to improve the manuscript. Moreover, I appreciate the valuable comments of the two pre-examiners, Dr. Peter Joore and Dr. Andrés Felipe Valderrama Pineda.

For a long time, I have wanted to express my heartfelt gratitude to my long-standing design professors, Professor Matthew Turner, Professor Philine Bracht and Professor Klaus Lehmann, for their guidance and patience in grooming me to be a responsible designer. My warmest thanks to my lifelong mentor, Professor Dieter Rams, who once said to me, “Go ahead with whatever is in your little brain.” That was in Kronberg in early summer 2014 – then I took a deep breath and plunged into my doctoral journey.

I want to express my special thanks to all my close friends around the world whom I have accumulated during my life journey for providing faraway but powerful support over these years. Last, to my adored parents, cherished sister and dearest brother.

Hong Kong, 3 May 2019

Luisa Mok

1. Introduction

1.1 Background

The year 2019 marks the centenary of Bauhaus, a design school that aimed to change society in the aftermath of the First World War by establishing standards for creating better design to improve people's lives (Siebenbrodt, 2000; Droste, 2019). Hoschshule für Gestaltung (Hfg) Ulm carried on the legacy of Bauhaus to put forward consciousness of the social responsibility of design in everyday societal activities through design practice and design research (Aicher, 1991; Lindinger, 1991). Later, individual design visionaries hoped to realise the potential of design for social and environmental sustainability through its capacity to envision future ways of living (design advocates, such as Fuller, 1969; Papanek, 1984 [1972]; Bonsiepe, 1977). March 2017 also marked the thirtieth anniversary of the Brundtland Report, Our Common Future (The World Commission on Environment and Development (WCED), 1987). The number of references to the word *design* contained in this landmark report – together with its promulgation of another noun, *sustainability* – brought together the terms environmental, appropriate, ecological, green and social design in one phrase: design for sustainability. Since then, there have been many ongoing efforts to advance design knowledge for sustainability. However, design solutions for sustainability are easily restrained from achieving their intended outcomes. Some examples can easily be recalled: Playpump, officially launched in 2000, addressed the wrong problems (Stellar, 2010), One Laptop Per Child, launched in 2005, underestimated the complexity of operating in the developing world (Rawsthorn, 2011), a sustainable landscaping project launched in 2004 failed to address interrelated societal issues (Booth and Skelton, 2011) and the Low2No project to achieve a low-carbon city, launched in 2008, did not foresee the problems it would face (Steinberg, 2015). In view of these results, is just creating a better design not enough?

Many reasons have been given for these design shortfalls. Yet, one key reason is that designers do not recognise that issues underlying sustainability are not easily resolved without fathoming the complexity of systems transitions. A major cause behind the predicament of design experiencing the restrained sustainability effect is the interconnectedness of systems. In the ongoing evolution of societal systems, diverse elements and activities interlock with each other (Hughes, 1983:79-105; Kemp, 1994; Kemp, Schot and Hoogma, 1998; Geels, 2002). Due to these interlocking relationships, changing only one component in a system without considering the systems dynamic may result in a futile attempt at achieving sustainability. The long course of the transitions pathway is unpredictable and even complex, which may lead to unpredicted future circumstances that restrain systems transitions. These adverse situations are conceptualised by Thomas Hughes (1983:79-105) as reverse salients; he warns that the possible outcomes of reverse salients may have a disastrous effect, impeding overall systems growth. A reverse salient is, in a figurative sense, the inverse of a salient, resembling the fallen section of an advancing military front line (Hughes, 1987:51-82). The concept underlines the fact that no single element can be isolated due to the socio-technical interdependencies inherent in systems and this hinders the growth of new systems. Reverse salients may develop if problems inherent in future circumstances are not estimated or, even if they are projected, cannot be easily tackled (Hughes, 1983:79-105). Furthermore, these situations arising in short-term future often do not have an immediate social and environmental effect but may lead to critical situations that cripple overall systems transitions. To facilitate transitions for sustainability, engaging in strategic design efforts to address the problems of future contingencies in sustainability transitions is of vital importance. This almost identifies a need for a strategic design approach to the short-term future projections in order to project the situations and, just as importantly, handle problems of reverse salients in systems transitions.

When speaking of the short-term future, it is hard to define exactly how long of a timeframe it refers to. Yet it might be workable to explain by defining the range of time in which future situations are possible to project and, in addition, associating it with the reverse salients concept. In this explanation, the short-term future lies within the range between "the situations that are at present" and "the far future situations whose reverse salients cannot be projected." The conceptual demarcation between these two domains is the locus of "the short-term future." This is the extent of the future in which reverse salients can be projected, which rightly implies that they can be tackled in certain ways if they can be estimated. Still, the definition does not have a real, absolute time frame. This is also due to the challenge that tackling reverse salients in the near future requires a new and methodological approach to anticipate and overcome them.

In the current decade, understanding of sustainability as a systems challenge has led to the emergence of new design research that adopts a systems perspective and links design to the socio-technical systems level for sustainability. A recent article on the evolution of design for sustainability has discussed the latest generation of the evolution as design for sustainability at the socio-technical system innovation level (Ceschin and Gaziulusoy, 2016). The phrase *socio-technical system innovation*, specifically from the field of transitions studies, is defined as a transition from one socio-technical system to another (Geels, 2005). Socio-technical systems describe the co-evolutionary development of societal and technological systems as well as their subsystems comprising multifarious ecological, cultural, economic and industrial activities that form into socio-technical systems (Grin, Rotmans and Schot, 2010:1-8). Due to the high complexity of systems transitions and the dynamics amongst multiple levels, new design approaches have been developed for sustainability transitions. With an urge to explore an approach to developing strategic design that targets problems underlying systems transitions, particularly reverse salient that can be projected, this emergent research work is reviewed and discussed to see if the work provides relevant support.

Before discussing the specified emergent research work, an earlier group of research on design for sustainability should be described even if it does not explicitly link design to socio-technical systems. This work – Ezio Manzini's strategic design for sustainability – is highlighted here due to its significance to advancing design for a systems perspective. In the last decade, Manzini (1999; 2003) proposed strategic design for sustainability to facilitate socio-cultural changes through production and consumption systems reconfiguration. This fundamental concept was developed with his research associates, including Anna Meroni and Carlo Vezzoli (Manzini and Vezzoli, 2003; Meroni, 2005; 2006; 2008; Vezzoli and Manzini, 2008). The concept developed several strategic design approaches to explore the interconnected activities of producers and consumers for systems reconfiguration. The approaches include Design-Orienting Scenarios (DOS) and Product-Service System (PSS) as well as strategic service design. These approaches brought forward future visions to the present through co-creating long-term, shared scenarios amongst producers and consumers and then, based on the scenarios, through co-designing platforms to foster behavioural changes from daily activities. Later, the concept has also expanded to a networking concept to co-create strategic networks to connect different local cases for realising larger-scale societal changes (Vezzoli, 2007; Jégou, 2010; Manzini and Rizzo, 2011). The concept firstly co-developed future sustainability visions with stakeholders, and afterwards facilitated local behavioural changes towards the shared visions by means of concerted efforts. This group of early design research represents a pioneering effort in developing design with a systems perspective for societal changes. In essence, the design approach of this early research brings forward co-created, shared long-term visions to the present to facilitate present-day behavioural changes towards far-future systems changes.

Now, this section returns to the emergent research on design for sustainability at the socio-technical systems level. Although this research started with a sprinkle of work, it develops design with a systems perspective by adopting theories from pertinent fields of study, such as network theory, social practice theory, living systems theory, theories of change, sustainability transitions theories, sustainability science and future studies. Most of them integrate transitions theories with design. An early collaborative study between design researchers and transitions scholars was conducted in 2008 (Vezzoli, Ceschin and Kemp, 2008). This groundbreaking study integrated transitions management theories with PSS. The study intended to expand PSS for sustainability from designing a solution to designing a favourable condition to support and scale up a niche innovation for mainstream systems. The study result proposed a concept of system maps of evolutionary stakeholders, involving the co-definition of transitions pathways with stakeholders for shared visions and use of the visions to facilitate innovation experimentation and diffusion through orienting a multi-stakeholder process. Later, the design researcher of the collaborative study, Fabrizio Ceschin, built on the initial concept and deepened the integration with Strategic Niche Management (SNM), Transitions Management (TM) and socio-technical experiments of transitions theories. A comprehensive model of multi-term strategic design, called the Strategic Design of Product-Service System, was developed (Ceschin, 2012; 2013; 2014). The concept co-defined long-term visions with stakeholders and, reflecting on the visions, developed a socio-technical experimentation process for PSS. The PSS design prompted short-term and mid-term change actions from stakeholders for behavioural changes towards long-term visions. The concept progressively scaled up innovation to the mainstream system on multiple time frames to ultimately replace dominant systems – this was named multi-term strategic design.

To comprehend systems transitions, Idil Gaziulusoy (2010) argued for a systems theoretical and strong sustainability perspective. She integrated design with transitions theories, sustainability science and future studies. In the integration, she refined multilevel perspective (MLP) and socio-technical scenarios (STS) frameworks from the field of transitions studies, supplemented with knowledge from the other aforementioned fields for developing system innovation. The socio-technical double-flow scenario method she developed guides the formulation of long-term business strategy that aligns with societal sustainability visions to inform short-term product development plans (Gaziulusoy, 2010; Gaziulusoy, Boyle and McDowall, 2013; Gaziulusoy and Brezet, 2015). Later, Gaziulusoy also put forward strategic design for urban transitions towards sustainable futures through participatory design visioning (Gaziulusoy and Ryan, 2015). The strategic design approach of Gaziulusoy develops future socio-technical scenarios with companies and based on these scenarios suggests long-term business strategy for devising short-term product development planning. In the same corporate context but with a varied strategic design approach, Peter Joore (2010) lifted design from creating function innovations to system innovations. The approach targeted the fulfilment of product functions and long-term societal needs through a multilevel systems approach. In his research, he adopted several concepts and models, including multilevel perspective (MLP), the concept of fit-and-stretch pattern and Arenas of Development (AOD) from transitions studies as well as several design and innovation systems models. The study result developed a multilevel design model (MDM) to support designers to interrelate multiple systems levels in society for the development of new products, PSS and other system innovations to meet longer-term societal needs (Joore, 2010; Joore and Brezet, 2015).

Joon Sang Baek, Anna Meroni and Ezio Manzini (2015) developed collaborative service design by designing social networks that favour collaboration amongst actors in order to build community resilience. They adopted Social Network

Analysis (SNA) and Degree of Collaboration (DoC) in the field of network theory to help understand social relations. The research developed a socio-technical systems design framework to conceive a series of desired long-term future outcomes through collaboration amongst stakeholders. Afterwards, they designed social networks that favour collaboration amongst stakeholders in order to generate solutions for building resilience towards the long-term visions. Abby Lopes and her associates used Transition Management (TM) and socio-technical experiments from transitions studies to facilitate sustainable sanitation transitions. The approach appropriated visual communication design to create far-future visions to inform new habits of toilet use (Lopes, Fam and Williams, 2012). Another study applied transitions theories to analyse sewage systems (Fam et al., 2009). Although they did not develop any design approach, Dena Fam and her associates studied the need of design to adopt a systems perspective for systems transitions. Last, there is also a design curriculum that integrates several existing theoretical, empirical and practical work on transitions into a “Transition Design” framework. The curriculum was developed by Terry Irwin, Gideon Kossoff and Cameron Tonkinwise at the School of Design at Carnegie Mellon University (CMU) (Irwin, 2015; Kossoff, Irwin and Willis, 2015; Irwin, Kossoff and Tonkinwise, 2015). As a curriculum, it does not develop any particular design model for sustainability at the systems level. Rather, its design pedagogy nurtures designers and design researchers to facilitate systems transitions at the systems level by drawing on multiple theories from varied fields of study – multilevel perspective (MLP) and niches experimentations from transitions theories, social practice theory, living systems theory, alternative economics and other theories of change.

In very recent research, Sampsa Hyysalo et al. (2019) built on the transitions arena (TA) of Transitions Management (TM) to develop mid-range planning for policy pathways. This resulted in their new mid-range Transitions Arena (mid-range TA). TA is originally intended for long-term planning but they redesigned it to formulate mid-range pathways through co-constructing interim visions with stakeholders by applying co-design tools. The concreteness of the interim visions specifies the mid-range actions – so-called pathway step-actions – which need to be taken in the medium time frame. The authors also defined mid-range planning as covering a time span of 13 years towards achieving long-term radical transitions.

At this stage, the current design research on socio-technical systems is reviewed to understand different design approaches developed to enhance design for sustainability. The current work builds design with a systems perspective for large-scale sustainability transitions and expands design knowledge through integration with other fields of knowledge, particularly transitions theories. Only by equipping these can design be sufficient to facilitate sustainability at the systems level. These two points supporting this research are evident. While in terms of foreseeing and handling problems of reverse salients, a key finding is furthermore discovered and analysed. This discovery tends to indicate that current design approaches are insufficient to support this research.

The finding is that most design efforts in current research are taken to support the development of long-term visions and goals. Even when there is a newly developed approach targeting mid-range visions, it would still not be adaptable to solve problems within the near future. The finding is elaborated below.

Most of the design approaches of the current research, although they are varied, are well developed with the concept of long-term projections. They generate visions of the long-term future through active engagement with stakeholders and based on the shared, co-created long-term visions to design strategic goals to facilitate present-day actions towards realising the future visions. However, design for sustainability cannot be limited to merely generating long-term visions or designing strategic actions that are detached from present-day concerns. As introduced at the beginning, the critical problems in transitions are those emerging in the near future – that is, reverse salients. To facilitate transitions for sustainability, strategic design developing short-term future visions is necessary. Having pointed out the majority of current design approaches in long-term projections, the most recent work by Hyysalo et al. (2019) makes an exception by targeting interim goals to develop mid-range TA visions. Given this recent work, the mid-range TA approach bridging long-term visions and present-day actions through mid-range planning may support this research that addresses the near future. The approach is a co-design process to co-construct medium-range visions with stakeholders through discussions and, based on the deliberate visions, to foster their own behavioural changes at present. Its objective is to empower key stakeholders with clearer visions by formulating more concrete policy pathways and co-designing step-actions for the shorter term. Having explained this, the approach of co-creating visions to empower key stakeholders would not be the same as creating visions to solve problems in transitions. A fundamental difference is that reverse salients are near-future visions that emerge in transitions dynamics. They are problems developing in the transitions dynamic in the short-term future during the course of systems growth, which are not to be co-constructed by stakeholders but can only be identified in systems transitions. Moreover, the type of future visions needed has to clearly visualise and clarify problems because they are not seen at present but can be foreseen to be forming. Equally as important, the future visions have to solve the identified problems because their adverse effects are developing in the short-term future and may eventually cripple overall transitions. In this way, the visions would have to be specific to clearly bring forward the major, critical problems to the present and effectively solve the problems in practice as well. This likely posits a strategic design approach with anticipatory strength as well as operational effectiveness in order to pre-empt adverse results. For these reasons, solving problems in the short-term future evidently demands a different orientation of strategic design than the one provided by co-design approaches.

The majority of design approaches supporting the empowerment of stakeholders with future visions has laid an important foundation for design research for sustainability. Strategic design for the short-term future is crucial to tackle reverse salients that have weighty consequences impeding overall transitions, as discussed. However, with respect to the complexity of problems inherent in the short-term future, the current design approaches would not be adaptable to overcome sustainability transitions obstacles in the short-term future. The concept of reverse salients has not been adopted by design research, but has relevance in the development of strategic design that facilitates the reorientation of transitions pathways towards achieving sustainable futures. Addressing reverse salients would fundamentally involve a particular adaptation of strategic design to the current approaches wherein the lack of support from current research has been made apparent. Exploration for a new design approach to successfully deal with problems emerging in the short-term future is then clarified.

1.2 Research aim and research objectives

The review on design for sustainability at the socio-technical system innovation level finds that the existing design for sustainability approaches are insufficient to deal with problems emerging in the short-term future in systems transitions. However, approaches meeting the challenges are indispensable to avoid adverse situations that will impede transitions. Understanding this need, this research sets out the basis by building on the current research on design for sustainability at the systems level by adopting a systems perspective and integrating it with other fields of knowledge. On this basis, the research contributes to a new research area of exploring an alternative strategic design targeting transitions problems in the short-term future. The research aim is defined as to learn to anticipate and overcome sustainability transitions obstacles in the short-term future.

To achieve the research aim, first of all, the type of sustainability transitions obstacles that may have prevented design from achieving its sustainability goals needs to be explained. Afterwards, to overcome the barriers, a particular design approach has to be developed for successful design in dealing with the problems and further organising the approach to clearly guide design practice.

To achieve the research aim, three research questions are formulated as follows:

1. Which are the critical phenomena of systems transitions that prevent design for sustainability from achieving its objectives?
2. How can design for sustainability identify and solve problems that are emerging in the short-term future?
3. What form of guidance can be provided for designers to meet the short-term future challenges in sustainability transitions?

Regarding the research area, this research studies design for sustainability with an approach that integrates two fields of study, namely transitions studies and strategic design studies. The literature review of transitions studies includes both transitions theories and social studies of technology for the concept of reverse salients. The review of the transitions literature draws theoretical insights into problems emerging in the near future in order to provide implications for design practice. This target sets the scope of transitions reviews to inquire into the fundamental transitions theories in order to be able to explain the structural problems in socio-technical systems, which leads to a deeper understanding of problems inherent in the short-term future. Reviewing strategic design offers practical insights into developing strategic design to develop short-term future projections. To implement short-term future planning, the review designates the operational elements of strategic design as the focal point of study. Insights from transitions studies and strategic design studies are then made available to integrate into the development of a new design approach for the short-term future for sustainability transitions. The diagram below illustrates the research area integrating transitions studies and strategic design studies (Figure 1. The research area).

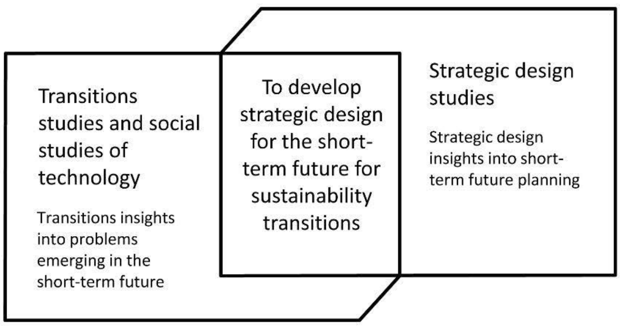

Figure 1. The research area.

The research method adopted to develop the new design approach is the case study method. The case study method is useful for developing a theoretical proposition from empirical observation. In this research, an empirically valid theoretical framework is developed to guide design practice for sustainability transitions. The primary target audience of the research consists of design researchers and academics who study strategic design for sustainability transitions as well as designers who seek to facilitate transitions for sustainability in their practice. The integrated knowledge on sustainability transitions created in this research may also be relevant for researchers beyond the design field, such as transitions researchers and transitions planners.

1.3 Structure of dissertation

This dissertation is structured to comprise seven chapters, including this introductory chapter. Chapter One, "Introduction," clarifies the research focus, sets the research aim and formulates the research questions guiding the fulfilment of the research aim. Chapter two is a "Literature review" that has three main sections. The first two sections are reviews on transitions studies and strategic design studies, respectively. They are reviewed to draw their key respective insights into problems inherent in the short-term future and short-term future planning. The third section puts the two sets of insights together to develop an initial design approach for the short-term future that is ready to be utilised in case studies. Chapter three, "Research method," explains the research strategy of applying case studies as a research method and describes the case study research process and methods used in this research. Chapter four, "Case studies," presents the two cases applying the initial design approach. At the end of each case, a within-case analysis is conducted to investigate the initial proposition through thorough description of the design processes. Chapter five, "Analysis of the two cases," analyses the application of the design approach in the two cases. The analysis discusses the initial theoretical proposition to determine its sufficiency to support strategic design for the short-term future. After the investigation, the empirically valid proposition will be developed into a genuine design approach for design practice to create short-term future planning to identify and overcome problems that emerge in the short-term future, which is accomplished in chapter six, "Strategic Design for the Short-term Future model: the six-stage design process." Chapter seven, "Discussion and conclusions," discusses the achievement of the research aim and questions, research contributions and limitations as well as future research directions suggested to build on this research. The dissertation ends with the conclusions.

2. Literature Review

This chapter presents an overview of literature in the two fields of study – transitions and strategic design – in order to derive insights from these bodies of literature with a view to developing a new design approach to enhance design for sustainability. First, a review of transitions literature is undertaken to explain the structural problems in transitions through comprehending the fundamental concepts of sustainability transitions. The explanation offers insights into problems arising in the near future and afterwards provides implications concerning sustainability transitions to enable design practice to anticipate and mitigate them. Second, a review of strategic design literature is undertaken to investigate the operational elements of strategic design that have an effect on the implementation of short-term future visions. The key insights provide implications for guiding strategic design to develop short-term future planning for sustainability. Afterwards, the respective theoretical insights generated through the literature of transitions and strategic design are integrated to explore a new design approach. This new design approach develops short-term future planning against reverse salients in order to facilitate transitions for sustainability.

This chapter comprises three main sections and a chapter summary: Section 2.1, Transitions literature, reviews transitions studies and offers theoretical insights. Section 2.2, Strategic design literature, reviews strategic design studies wherein design insights are provided. Section 2.3, An initial design approach to strategic design for the short-term future, develops the two sets of theoretical insights into design implications and puts them together to present an initial design approach. The last section is a summary of this chapter (Section 2.4).

2.1 Transitions literature

With regard to integrating knowledge to enhance design for sustainability at the socio-technical systems level, this section reviews transitions theories in the context of socio-technical systems. This review explores how to anticipate problems in transitions through reviewing the fundamental theories of transitions from the transitions literature. In addition, the concept of technological transitions in the field of social studies of technology (also known as science and technology studies (STS)) is also reviewed to fathom problems arising in the course of new systems growth. Both transitions studies and social studies of technology discuss transitions from a systems approach, which align with the aim of this research to enhance design for sustainability at the systems level. At the end, the review findings are analysed to develop transitions insights to inform the current theory of design for sustainability transitions and provide implications concerning sustainability transitions for design practice.

Targeting reverse salients arising in transitions, this review begins from understanding the fundamental concepts of transitions theories. The fundamental theories give a thorough explanation on how the problems in socio-technical systems are caused by specific patterns and interaction mechanisms that are firmly embedded in the systems. From the fundamentals, the nature of problems in socio-technical systems is revealed. These problems characterise transitions as arduous processes when shifting to new systems. In this way, analysing the characteristics of the structural problems in socio-technical systems yields understanding to comprehend the complex network of systems transitions, which offers insights into developing design interventions regarding emergent problems.

Before starting the discussion of transitions, it is necessary to clarify the justifications for adopting transitions theories for this research. In addition to building on the emergent design research that integrates transitions knowledge with design, the fundamental premises of transitions theories also provide rationales for the selection. Transitions studies target sustainability as the normative goal for systems transitions (works include Elzen, Geels and Green, 2004:282-300; Smith, 2006; Geels, 2014; Darnhofer, 2015; and many others), which is appropriate to this research. They also recognise technology as having a key role in sustainability transitions, without disregarding the importance of addressing environmental issues in conjunction with societal challenges. Moreover, the studies exploit the relationships between societal and technological development instead of focusing either societal or technological advance for change. This develops the socio-technical perspective of transitions theories to unfold the complexity of sustainability transitions. These premises justify using transitions studies to support this research. In addition, the concept of technological transitions in the field of social studies of technology – in particular the concept of reverse salients – is taken up. The concept of reverse salients deepens the understanding of the criticality of problems that would lead to adverse consequences without deliberate intervention.

In addition, an article published in 2012 provides an overview of the remarkable growth trend in sustainability transitions research since the late 1990s (Markard, Raven and Truffer, 2012). In addition to publications on this subject, there are international conferences, exchange networks and research units (for example, Sustainability Transitions Research Network (STRN) and Science Policy Research Unit (SPRU)) in the research community to increase knowledge exchange through discussions, reflections and criticisms. With this background, transitions literature offers a scholarly account of theories to comprehend transitions when expanding design knowledge for sustainability.

When using transitions studies, the focus is on fundamental transitions theories of socio-technical systems. As fundamental theories form the basis of this review, some practical approaches to socio-technical systems studies are excluded, while it is understood that those approaches would also enhance design for sustainability transitions. For example, the management and governance approach of Strategic Niche Management (SNM) studies how to strategically manage and monitor innovations to enhance structure shift to sustainability (Kemp, Schot and Hoogma, 1998; Kemp, Rip and Schot, 2001). Also, technological innovation systems (TIS) studies how to improve innovations systems from a technological perspective (Markard and Truffer, 2008; Raven, 2017). These practical approaches have also been adopted by some design research, for instance, SNM by Ceschin (2012; 2013; 2014) as discussed in the last section of the design for sustainability review. Yet, in order to enable design to have a theoretical underpinning on sustainability transitions, the fundamental theories on how problems emerge in transitions as well as how a transition is produced are of paramount importance. Therefore, this transitions review has selected the fundamental transitions concepts from the transitions literature and social studies of technology.

This review is divided into three parts. The first part investigates the fundamental concepts of transitions theories to explain the structural problems in transitions on the basis of transitions theories (Section 2.2.1). Attaining transitions fundamentals, the second part carefully analyses the characteristics of the structural problems in socio-technical systems and the concept of reverse salient (Section 2.2.2). Having gained in-depth understanding of transitions problems, the last part offers transitions insights into anticipating problems in transitions, which provide implications for design practice for sustainability (Section 2.2.3).

2.1.1 The fundamental concepts of transitions theories

Regime formation and stabilisation

This section gives a brief and concise explanation of the fundamental concepts of transitions theories, beginning from the root of the concept of socio-technical systems. The explanation of the root and fundamentals will not focus on the historical details. Rather, this section explains how the basis of transitions theories provides an understanding of the structural problems in transitions; afterwards, the ideas can be synthesised to arrange the problems into major ones for further discussion.

This section contains two parts. The first part explains the formation and stabilisation of the regime, while the second part describes the systems transitions and niche breakthrough. Before proceeding further, the usage of two terms is clarified here. The meanings of the terms *regime* and *niche* are relatively specific in the transitions literature; the respective two terms can be commonly referred to as *dominant systems* and *new systems*. Throughout this dissertation, the terms dominant systems and new systems are chosen to be used as they are more widely understood. In some parts of this dissertation, where specificity to the transitions literature is necessary, the terms regime and niche are also applied.

Transitions theories are rooted in the evolutionary theory of economic change and science and technology studies (STS) (Geels, 2002). This paragraph outlines the concepts of the rise of paradigms, regimes and socio-technical systems and the problematic issues that emerge from them. Thomas Kuhn uses scientific paradigms as a metaphor to depict the process of normal science (Kuhn, 1996 [1962]). The process forms an inherent logic and establishes a paradigm within the science community. As a result, scientific paradigms reinforce themselves and often suppress novel research. Kuhn's scientific paradigms are later taken up by Giovanni Dosi. Dosi (1982) states that science research is comparable to technological development, in which "technological paradigms have a powerful exclusion effect" (Dosi, 1982:153). The technological paradigms referred to by Dosi involve a complex structure of interactive mechanisms operating amongst technological, economic and social variables. Richard Nelson and Sidney Winter (1977) state the inner logic of innovation in their study on the Research and Design (R&D) innovation process at organisation level. The inner logic comprises the cognitive rules that restrict selections of achievable technology by engineers. The logic sets "natural trajectories" (Nelson and Winter, 1977: 56) and forms the "selection environment" (Nelson and Winter, 1977:49) for the market that is favourable for regimes, which results in "technological regimes" (Nelson and Winter, 1977:57). Renate Mayntz and Thomas Hughes define technological systems as "large technical systems" (Mayntz and Hughes, 1988) containing interlocking heterogeneous elements to explain the inherent logic of regimes stabilisation. The concept is vividly captured in his phrase "seamless web" (Hughes, 1983:282). Expanding to the societal context, transitions researchers in the mid-1990s discussed paradigms using the concept of "socio-technical systems"; they stressed the co-evolutionary development of society and technology. These co-evolution processes are inherent in systems in which the systems are eventually consolidated as a socio-technical regime (Kemp, 1994; Rip and Kemp, 1998). Progressively, the self-reinforcing patterns develop into strong path dependencies and cause lock-ins in systems (David, 1985; Unruh, 2000).

Although the evolutionary theory of economic change underlies transitions theories, transitions theories carry forward the significant implications of regimes formation and stabilisation to the broader societal context for systems transformations and explore ways in which a niche can break through into the regime. The following explains the fundamental transitions concepts of socio-technical systems.

In transitions research, co-evolution is a central concept of transitions to explain the formation and stabilisation of socio-technical systems. The processes of societal and technological development consisting of diverse components and activities are co-evolving in societal structures in many ways (Kemp, 1994; Geels, 2004; 2010). This develops the complexity of changeable dynamics in systems. Although they contain diverse components and activities, the co-evolving processes are indeed underlain by specific transitions routines that self-reinforce the structure. The specific routines gradually set preferable trajectories due to path dependencies and lock-ins that transform and maintain the structure (Nelson and Winter, 1977; David 1985; Unruh, 2000). Underlain by strong transitions routines, the diverse yet interconnected elements and activities co-evolve in the systems to reinforce each other to maintain the structure aiming at fulfilling a system goal (Hughes, 1983:79-105; 1987:51-82; Grin, Rotmans and Schot, 2010:1-8). This develops the co-evolving determinate nature of transitions (Grin, Rotmans and Schot, 2010:1-8). Understanding the facilitation of systems changes as co-determinate processes implies that in most cases it is not enough to merely produce a better single design. Rather, a range of associated changes is required in socio-technical systems (Hughes, 1983:79-105; 1986; Shove, Pantzar and Watson, 2012).

The concept of co-evolution in systems is articulated and conceptualised further through a multilevel perspective (MLP). MLP is an analytical framework to analyse transitions from a multilevel perspective in a configuration (Figure 2. The multilevel perspective (MLP) configuration rendering the systems transitions and the dynamics interplaying between the three levels). It analyses specific systems transitions through rendering the interplaying dynamics in complex socio-technical systems (Geels, 2002; Geels and Schot, 2007). Configuring many interferences of processes with interconnected and interdependent activities, MLP emphasises the alignment of trajectories within and between levels to produce a transition (Geels, 2002; 2006; Grin, Rotmans and Schot, 2010:1-8). MLP configuration nests three levels of functional activities – niche innovations, socio-technical regime and socio-technical landscape. The three levels and their activities are briefly summarised: the micro level of niche innovations is the protected space to incubate innovations until maturity for diffusion to the socio-technical regime. The meso level of socio-technical regime is the established structure that maintains, reproduces and transforms the dominant form of the systems. These reinforcing activities often resist niche innovations, which can thus make almost no headway for a niche breakthrough. Only at a contingent point when innovations are available from niches, internal tensions arise within regimes and pressure from the landscape ushers in changes, a window of opportunity is created for niches to advance to break through into the regime (Geels, 2002; Geels and Schot, 2007). This allows an innovations breakthrough for a new systems configuration. The macro level of socio-technical landscape is an external environment containing slow-changing factors. It provides the context to enable or restrain the niche and regime activities but is not influenced by them in reverse. The functional activities illustrated at three levels unfold the patterns and underlying mechanisms of interacting activities within each level. Over the course of time, the co-evolution interactions form trajectories to maintain a functional societal structure in order to direct systems to achieving goals. This to a great extent reveals the complexity of interconnectedness and interdependencies in systems. In this way, interacting elements and activities constitute great transitions dynamics in which almost no single element is free from interferences. This also explains that change in one system element impacts on others, and these impacts can both restrain and enable each other (Hughes, 1983:791-105; 1986).

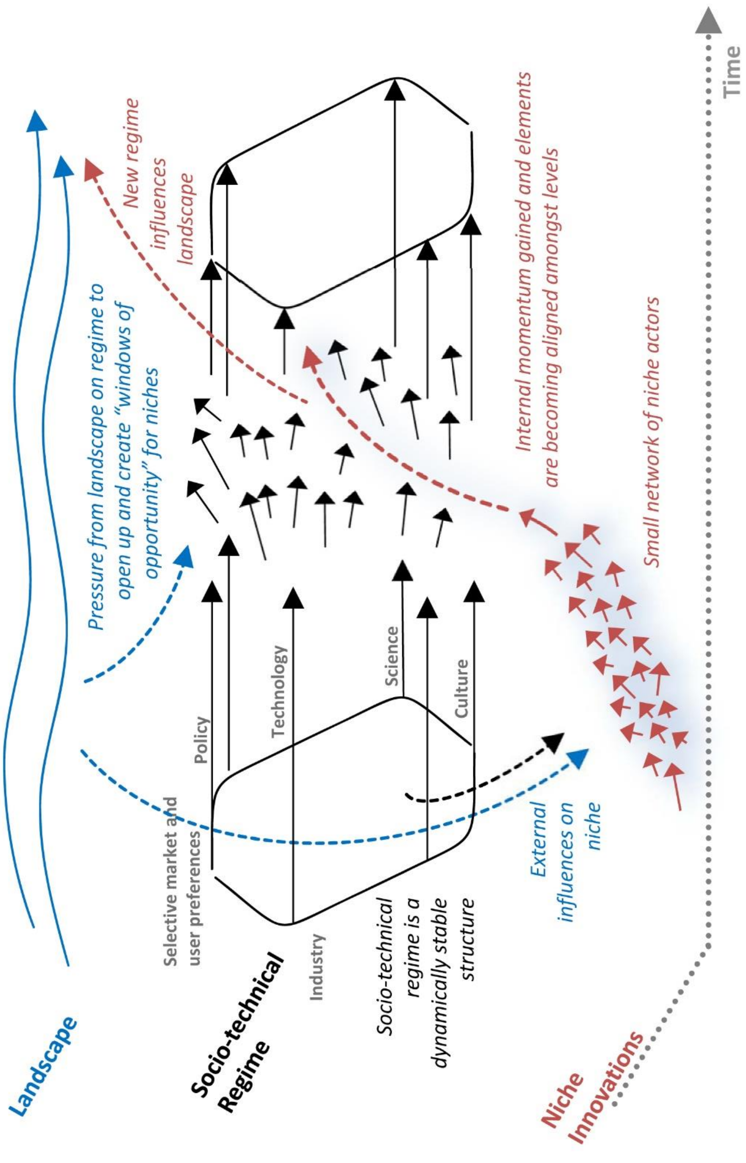

Figure 2. The multilevel perspective (MLP) configuration rendering the systems transitions and the dynamics interplaying between the three levels of niche innovations, socio-technical regime and socio-technical landscape, adapted from Geels and Schot (2007, p.401).

The above concepts all indicate that the current environment of socio-technical systems has always been configured to favour the current dominating systems. As a result, whenever new systems build on the current environment, the preconfigured environment powerfully prohibits new systems from burgeoning due to its strong exclusion effect.

Systems transitions for niche breakthrough

The above has explained the formation and stabilisation of socio-technical systems. How, then, do transitions happen for niche breakthroughs to replace the current socio-technical regime? Socio-technical systems are dynamically stable as understood, yet they are also continuously challenged by alternatives (Beckhout, Smith and Stirling, 2004:48-75). This part studies the particular transitions patterns and pathways shifting from one socio-technical system to another.

The framework of MLP has illustrated transitions analysis from a multilevel perspective, yet the framework is not limited to analytical purposes but also has its prospective strength. This prospective strength does not mean that analysis is prediction, but rather that analysis is based on variations in the timing and nature of multilevel interactions to prospect for transitions projections (Geels and Schot, 2007). In its analytical strength, MLP configures many interferences of processes with changing interdependencies, which emphasises the alignment of trajectories within and amongst levels to produce a transition (Geels, 2002; 2006; Grin, Rotmans and Schot, 2010:1-8). With a focus on processes, the dynamics configuring within and amongst levels project how patterns and interaction mechanisms emerge and stabilise in systems in order to maintain a functional societal structure (Geels, 2002). Underlying these transitions dynamics, an opportunity is also created for a niche breakthrough. This is achieved when an interfacing point in transitions is available: at a time when niche innovations are ready for wider adoption, substantial landscape pressure is put on the regime and internal tensions are created within the regime (Geels, 2002; Geels and Schot, 2007). In addition to analysing past transitions, MLP in its prospective strength also analyses the ongoing transitions situation. From the process perspective, the framework analyses future transitions projections that set strategic directions for niche efforts to foster transitions.

Since the introduction of MLP, there have been some criticisms about its way of investigating socio-technical transitions; in response, the author has made clarifications to further improve the concept (Geels, 2011). One of the criticisms is that MLP, due to its structural, definite three-level configuration, has oversimplified systems transitions, which compartmentalises actors in their specific levels in a way that is not likely in reality[1] (Jørgensen, 2012). In this line of criticism, MLP is argued

[1] The author in turn suggests a flat analysis of Arena of Development (AOD) contrasting to the level analysis of MLP (Jørgensen, 2012).

to disregard interlevel relationships, thereby ignoring interlevel dynamics that could be the essential source for systems change[2] (Murphy and Smith, 2013). MLP is also criticised for its excessive emphasis on technology to define regime and niche without considering other analytical choices for systems analysis[3] (Pineda and Vogel, 2014). The concept analyses the widespread long-term changes and this is criticised as ignoring attention to local processes[4] (Murphy and Smith, 2013). In addition, the analytical framework is frequently criticised for its lack of practical implications (Jørgensen, 2012; Murphy and Smith, 2013). Being aware of these criticisms, other concepts and methods of analysing systems transitions should be considered in addition to MLP. Not only does it aid in the analysis of transitions, integration with pertinent knowledge may also be able to operationalise the analytical and prospective levels of MLP to provide further practical implications to facilitate transitions.

Assisted by MLP, four transitions pathways are studied to suggest projections for transitions based on various combinations of different timing and nature of multilevel interactions (Geels and Schot, 2007). The four suggested transitions pathways are: (1) transformation pathway, which is mainly the orientation within the regime because niche innovations are not yet ready and pressure from the landscape is only moderate; (2) dealignment and realignment pathway, which are the times when the regime begins to dealign with dominant systems and the niche prepares for realignment. This happens due to great landscape pressure while at the same time several niches co-exist until one presides over the others to form into a new regime. (3) Technological substitution, which is the contingent opportunity when windows of opportunities are created for a niche to replace the regime. This requires both substantial landscape pressure and readiness of niche innovations. (4) Reconfiguration pathway, which is a combination of old and new technologies when the regime adopts niche innovations and this uptake triggers internal alternations, which ultimately leads to the reconfiguration of the regime. Systems transitions usually take place in a sequence, as described above. The typology of transitions pathways focusing on processes of multilevel interactions in systems provides an understanding of generic systems transitions patterns, which in turn may indicate future transitions paths.

MLP studies the role of processes in systems; some studies focus on the role of interlevel interactions in systems transitions and they suggest different transitions pathways for the multilevel interactions. The concept of interlevel interactions focuses on niche-regime connecting processes instead of seeing niche-regime relationships as dichotomous (Smith, 2007). In this view, niche-regime dynamics are leveraged as essential sources for systems change, which provides a broader perspective to identify opportunities for systems reconfiguration (Smith, 2007). The transitions patterns,

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[2] The authors hence focus on the niche-regime dynamic that develops the concept of niche-regime translation (Murphy and Smith, 2013).

[3] In their specific transportation study, the authors suggest other roles for defining niche to analyse transitions, including urban space and culture (Pineda and Vogel, 2014).

[4] The authors further venture into the deeply contested space of the niche-regime interlevel, adding resource peripheries dynamics to investigate systems transitions (Murphy and Smith, 2013).

namely translation sustainabilities between the niche and regime, include three kinds of translation: (i) opposition, wherein regime problems are translated to niche creation, (ii) adaptation, whereby niches learn socio-technical practices and adapt to regime settings, and (iii) alteration, in which the transitions context is changed, such as due to the exertion of massive external pressure from the landscape, which results in the regime appropriating it to make changes (Smith, Stirling and Berkhout, 2005; Smith, 2007). The translation patterns of niche-regime interactions are associated with the concept of transferability in which niches are stretched and transformed within the regime for systems change (Smith, 2007; Smith and Raven, 2012).

Regarding niche-regime interlevel changes, there are also variations of the concept from other studies. For example, empowerment, reconstellation and adaptation explain three patterns of transitions generated from the interactions between niches and regime (de Haan and Rotmans, 2011). Other varied concepts to distinguish three transformation processes are: (a) the niche to niche-regime pattern, wherein niches develop to erode the regime, (ii) the niche-regime to regime pattern, in which niches are combined with the regime to evolve into a new regime, (iii) the regime to niche-regime pattern, in which a substantial change happens within the regime due to external pressure from the landscape or competition from niches to violate the regime (Rotmans and Loorbach, 2010, cited in Grin, Rotmans and Schot, 2011:135-139).

Transitions are also long-term and non-linear processes (Grin, Rotsman and Schot, 2010:1-8). This non-linear development of transitions shifting from one stable structure to another is expressed in a multi-phase framework by transitions theorists to explain how transitions alternate phase by phase. These transitions pathways take a governance approach. The framework is formulated in a four-phase transitions model, namely the S-curve model (Rotmans, Kemp and van Asselt, 2001; Kemp and Rotmans, 2009). The four phases are the pre-development, take-off, acceleration and stabilisation phases. The S-curve model is used as a policy and regulatory framework to guide the modulation process of transitions. Examples of policy and regulatory frameworks are: Strategic Niche Management (SNM) (Kemp, Schot and Hoogma, 1998; Kemp, Rip and Schot, 2001) and technological innovation systems (TIS) (Markard and Truffer, 2008; Raven, 2017). The development of long-term transitions consists of fast and slow dynamics. The fast and slow development of change forms non-linear transitions pathways (Rotmans, Kemp and van Asselt, 2001). Due to this non-linearity, facilitating transitions requires progressive interventions in different sizes, speeds and time periods at various phases in the ongoing transitions processes (Rotmans, Kemp and van Asselt, 2001). The three system dimensions of size, speed and time period form an S-curve transitions path. The non-linear transitions path implies that the scale of the intervention can vary from large to small as long as it is strategically focused to improve and orient transitions towards sustainable goals. This clarifies that even relatively modest efforts can contribute to ongoing sustainability transitions in a large-scale systems transition.

Transitions are long-term processes owing to the great stability of the dominant structure in socio-technical systems, which makes transitioning from the current dominant systems to new systems slow. Transitions scholars state that the length of these processes – from upsetting the current dominant structure to stabilising new systems – usually covers at least 25 years (Rotmans, Kemp and van Asselt, 2001). Moreover, in the long process of transitions, the gradual destabilisation of the dominant structure until an eventual transition is achieved requires interventions at multiple phases for orientation (Grin, Rotmans and Schot, 2010:1-8). In addition, the long-term process is characterised as malleable due to socio-technical interdependencies in systems (Geels, Hekkert and Jacobsson, 2008) and recursive (Voß, Smith and Grin, 2009), which implies that strategies and measures cannot be rigid, but must be kept flexible to enable possible shifts to orient pathways (Voß, Smith and Grin, 2009).

Although with a varying degree of focuses on exploring transitions patterns, these studies all suggest the development of a systems perspective to scrutinise the interferences and alignment of processes within and between levels in systems for producing a systems transition. In addition, transitions pathways comprise a long and indefinite process that requires interventions at multiple phases.

This section investigating the fundamental concepts of transitions theories has explained how a regime is formed and stabilised, and also how systems transitions in which a niche breakthrough replaces the dominant structure can happen. The former highlighted concepts of co-evolution explain the preconfiguration of the socio-technical environment that is favourable to the regime and concurrently excludes niches. This explains why transitioning from the current socio-technical systems to new ones is difficult. The second part in turn introduces the concept of multi-phase and multi-level, proposing various potential transitions pathways for systems transitions. Based on the fundamental understanding of socio-technical transitions, the next section sheds light on the structural problems in transitions and, furthermore, the concept of reverse salients for yielding insights into anticipating the future adverse situations that can be projected.

2.1.2 The structural problems in transitions and the concept of reverse salients

This section places the focal point of discussion on the characteristics of problems in socio-technical systems through deepening the understanding of the fundamental transitions theories. This allows interpreting the problems in socio-technical systems and arranging them in terms of three major problem characteristics.

Problems are persistent

Stabilising systems results in the emergence of socio-technical interdependencies interlocking in the co-evolving processes that are firmly embedded in systems. These interlocking relationships cause the persistence of problems in systems and, as a consequence, increase resistance to changes; this restrains niche innovations, which makes shifting to new systems very hard. This implies that any new system building on this established systems environment will be restrained, which also implies that any systems transition shifting from the dominant systems has to proceed by overcoming barriers that often prevent the growth of new systems. However, there is considerable resistance against changes in systems transitions not only from the regime but also from the niche. Issues of resistance to changes from the niche are very often underexplored in transitions research. The main reason for this is that most studies ideally embrace the niche as the main driver for changes, with less of a focus on the underlying problems within the niche (Smith, Fressoli and Thomas, 2014). Problems of niche resistance to transitions can be due to, for example, uncertainties (Murphy and Smith, 2013), unfamiliarity (Kemp, Schot and Hoogma, 1998) and false assumptions or biased opinions (Marin, Stubrin and Zwanenberg, 2014; Mok and Hyysalo, 2017; Mok and Gaziulusoy, 2018) of key stakeholders when they are coping with changes in the indefinite future. Moreover, socio-technical systems evidently involve a diversity of stakeholders from various domains (Kemp, 1994; Geels, 2004; 2010). These stakeholders have different interests, future visions and priorities over the principles of sustainability and solutions (Smith, Stirling and Beckhout, 2005; Geels, 2010). This diverse view is easily developed into conflicting and contesting values in systems, which is due to the fact that value conflicts are inherent in systems (Hughes, 1983:79-105). The fact of resistance to change from the niche puts further curbs on the already restrained sustainability transitions.

Niche resistance to changes is further accentuated in the arena of niche-regime inter-levels where the niche is prone to fluctuations in both regime resistance and internal niche conflicts. This contesting area, conversely, is utilised and developed into the concept of transferability (Smith and Raven, 2012). The concept involves stretching and transforming innovations within the regime through leveraging niche-regime dynamics at the inter-levels as a source for changes. Transferability comprises activities of creating and exploiting tensions within the regime in order to enable niche innovations to be embedded into it and eventually replace it (Smith, 2007; Smith and Raven, 2012). Doing so requires empowerment of niches as well as ensuring that innovations are well aligned with the markets, regulations, policies, infrastructure and other aspects that are favoured in the regime. For innovations to effectively adhere to the configuration of the regime, this requires an identification of niche-regime shared elements, such as interests, values, beliefs, practices, desires and expectations (Smith, 2007). Investigations could be assisted by MLP to unfold the high complexity of systems dynamics at inter-levels for alignment of systems elements and activities in order to achieve a transition. In this understanding, niche-regime dynamics comprise a source of change that can be leveraged to reduce resistance to transitions as well as enhance niche innovations development.

The concept of co-evolution has explained how the persistence of problems is caused in transitions and how that increases resistance to changes from both the regime and niche.

Problems are unforeseen

As discussed, in the dynamically stable socio-technical systems, the co-evolving processes of societal and technological systems are developing. As a matter of their interacting dynamics with each other, their development is contingent. Future contingencies of societal and technological development subsequently steer systems in unpredictable directions (Hughes, 1983:79-105; 1986). Together with a force from the external environment that involves ecological, cultural, economic, industrial and other systems and institutions wherein they also co-evolve with their variables in many ways, systems are pushed in any direction and at any time in an expanding system. This further heightens the fact that the growth of a new system cannot be definite, but may move in any direction. Due to the unpredictability of future contingencies of development in systems, some problems inherent in future circumstances will neither be seen nor be easy to deal with. However, to facilitate transitions in this long process to prevent them from moving in any direction, problems in the near future have to be estimated and solved in order to orient the pathways towards sustainability targets.

When transitions are characterised by unforeseen problems, this means that the problems inherent in near-future outcomes are not being anticipated. In systems development, these are problems in systems that have to be tackled because they would otherwise result in inferior quality of uneven growth that limits systems development (Hughes, 1983:79-105). Hughes conceptualises uneven growth of elements in systems as elements that fall behind the growth of the new system and in a figurative expression depicts the concept as "reverse salients" (Hughes, 1983:14). In socio-technical systems, the elements that fall behind involve both technical and societal elements, such as technologies, markets, practices, legislation, infrastructures, lifestyle and social beliefs, as mentioned earlier. The expression of reverse salients denotes an inverse of a salient. The term – borrowing from military language describing the fallen back section of an advancing military front line – is an analogy for the irregular and indefinite growth of systems. Reverse salients are underperforming systems elements that are not advancing together with elements in the goal-seeking systems to maintain a functional societal structure. Due to this reason, they limit the growth of systems. Crucially, reverse salients arise in the dynamics of systems growth wherein their results are not currently present but will be produced in the short-term future. Crucially, Hughes warns that issues of reverse salients developing in erratic systems dynamics will eventually hamper overall new systems growth.

> *"... reverse salients arising in the dynamics of the system during the uneven growth of its components and hence of the overall network"* (Hughes, 1983:14).

Undesirable future situations are caused by the fact that socio-technical interdependencies are interlocked in co-evolving processes wherein one element of the systems implicates another. As discussed in the earlier sections, no single element can be isolated in systems.

> *"All of the systems, it is important to stress, share the characteristic of interconnectedness – that is, a change in one component impacts on the other components of the systems"* (Hughes, 1983:6).

As understood, reverse salients are adverse situations arising in the dynamics of systems growth. The situations can critically cause disastrous results in the near future that will eventually impede overall new systems development. As they are crucially important to facilitating transitions, this provides a compelling reason to study reverse salients to analyse adverse situations that may develop in the near future. Furthermore, creating interventions to remove reverse salients is necessary for new systems advance. In systems, gaining momentum and overcoming barriers in the course of growth are two key factors to expand systems (Hughes, 1983; 1987). A new system acquires momentum to adapt to current systems at the beginning of its growth. Yet growth momentum can be impeded when reverse salients gradually develop within systems. Being interlocked in the co-evolving processes in systems where reverse salients are currently not present but are emerging, barriers that would impede new systems growth have to be overcome before momentum is lost. Issues of reverse salients apparently pose a challenge for sustainability transitions. Grasping their interdependent and unforeseen nature as well as the potential situations in which they may cause adverse results in the near future, reverse salients have to be strategically targeted.

Attempting to maintain new system development requires diagnosis of reverse salients that will become critically disastrous, hampering overall new systems growth. Problems in reverse salients can be reflected in contemporaneous occurrences with the transitions situations at present. Hughes illustrated this point clearly by narrating the growth of the new electricity supply system from the late 19th century to the early 20th century (Hughes, 1983:79-105). In his study, he diagnosed the reverse salients of distribution costs for the new electricity system in 1882, as the new system would not have a market unless the costs were reduced. In this case, the reverse saliency was reflected in the scepticism of the majority of engineers about long-distance electricity transmission without storage batteries. This implied that a low-cost solution was unlikely to be realised by them, which potentially developed a reverse salient. The reverse saliency of distribution costs was also reflected in three almost simultaneous patent applications for a three-wire system to lower the cost of long-distance transmission. The three inventions reflected a reverse salient for the earlier concept of the two-wire feeder-and-main system which still had high costs and would not correct the reverse salient. Neither the adoption of storage batteries nor the application of a two-wire system would completely correct the reverse saliency of the high distribution costs of the new electricity system. Furthermore, the development of the new electricity system would not succeed without the successful implementation of lower-cost distribution. Only the launch of the radical solution of the alternating current system eventually corrected the reverse salient of high distribution costs. When facilitating new systems growth, the challenge lies in diagnosing reverse salients from contemporaneous occurrences due to their unforeseen nature. Equally important is an alternative and working solution to completely correct reverse salients; otherwise the new electricity system will not grow as narrated by Hughes.

Problems are critical

The concept of reverse salients by Hughes (1983:79-105) is associated with a correction plan to remove the diagnosed reverse salients. Targeting reverse salients tends to be a complex form of problem solving. Furthermore, they are problems of systems that are problems not at present but arise in systems dynamics. This makes facilitating transitions particularly challenging. To solve them, it is suggested that reverse salients should be defined as critical problems (Hughes 1983:79-105). In this way, problem solving in systems becomes a category of "critical-problem-solving activity" (Hughes 1983:80). Being defined as critical means that problems inherent in reverse salients would critically lead to adverse results; being defined as problems implies that they can be corrected with a solution. Returning to the case of the new electricity system, it was by defining the high distribution costs as a critical problem that resulted in the creation of a radical solution to completely correct reverse salients. The new system could have a market to grow only when transmission was achieved at an efficient cost.

Problems being defined as critical also has a corollary regarding the timing of interventions. This implies that the timely diagnosis of reverse salients and subsequent early correction plans are essential to correct reverse salients before they impede systems growth. As learned from transitions fundamental theories, the long-term and non-linear characteristics of transitions processes also require interventions to be pre-plans covering a short-term time frame rather than pre-planning for the entire course of systems transitions. Moreover, the indefinite nature of transitions also requires preparing plans from small to large scale as long as the efforts can contribute to the ongoing sustainability transitions of a large-scale systems transition. Overall, this framing of reverse salients as critical problems demands timely diagnosis of reverse salients and early, alternative and practical solutions in any scale to remove reverse salients through solving critical problems.

The unique concept of reverse salients with its associated critical problems has been moderately adopted by scholars for studying systems growth in large technical systems since its introduction by Hughes in 1983. Regarding the usage of the term "reverse salients," there are also other terms, such as technological imbalances, bottleneck or disequilibrium, which closely describe an uneven growth situation in a technological system. However, these terms are still incomplete to express the interdependent, unforeseen and critical nature of problems arising in large-scale systems. For example, the terms “technological imbalances” (Rosenberg, 1969:7) or “technical imbalances” (Rosenberg, 1969:6, 7, 10) suggested by Nathan Rosenberg represent a concept that is very similar to reverse salients. His study features situations caused by problems in the processes of technological change, and some imbalances require correction before an innovation could be fully utilised. In most cases, the correction would lead to remarkable improvements or future, radical innovation (Rosenberg, 1969). In this explanation, the term “imbalances” represents a very similar concept as reverse salients. However, Rosenberg’s focus on the machine industry has defined the term as referring to imbalances amongst technical components of machines regardless of societal and other components. Being focused on the machine industry, “technological imbalances” or “technical imbalances” would be incomplete to describe uneven growth situations in large-scale technological systems that involve diverse elements of various types. There is another comparable term, “bottleneck,” which has also been used by Rosenberg (Rosenberg, 1976:201). In correspondence with that, Hughes commented that a bottleneck is “geometrically too symmetrical” (Hughes, 1983:79). This implies that the term cannot fully express situations in the indefinite and contingent nature of large technical systems. An alternative term, “technological disequilibria” (Rosenberg, 1969:11), has also been used. Hughes made a comment on disequilibrium, as the term may have been reduced to a relatively simple concept of physical science (Hughes, 1983:79). Although this term associates imbalance conditions with opposing forces, it too may underrepresent those unforeseen situations arising in the dynamics of systems interdependencies. To sufficiently explain and understand future situations developing in transitions dynamics that may have the worst results, the term reverse salients and its concept are adopted in this research.

Having introduced the concept of reverse salients in previous paragraphs, a definition of the concept is given below for the purpose of this research. Fundamentally, reverse salients denote underperforming systems elements that are not advancing together with other elements in systems. The elements involve both technical and societal elements denoting technologies, markets, practices, legislation, infrastructures, lifestyle and social beliefs. In the context of sustainable systems, the elements interact with each other to advance together in order to maintain a functional structure for sustainability. However, due to the interdependent and unforeseen nature of systems growth, the elements fallen behind (that is, reverse salients), would develop into issues of reverse salients in the near future to eventually hamper overall sustainability transitions. In a nutshell, reverse salients can be defined as the future adverse circumstances developing in the near future in transitions, which may lead to disastrous consequences that eventually impede overall systems transitions. From the definition, some defining characteristics of reverse salients are displayed. Reverse salients are implied by (i) interdependent systems elements interlocking in socio-technical systems interdependencies; (ii) any type of elements in systems including both technical and societal elements; (iii) underperforming systems elements in the frontline of new systems that are not advancing together with others; they are (iv) developing in transitions dynamics in the future during the course of the systems growth process, which thus need to be gradually overcome; (v) their adverse effects are not currently present but will arise in the short-term future; and (vi) usually unforeseen, but are difficult to tackle even if they are foreseen. The definition of the concept of reverse salients and the six characteristics offer a basis to understand and identify reverse salients, which works towards developing mitigation to prevent adverse situations developing in short-term.

In regard to applying the reverse salients concept to large technical systems research, a review shows a steadily growing trend in its application during the period from 1983 (since the introduction by Hughes) to 2008 (Dedehayir, 2009). In the review, it is discussed that most research addressing reverse salients over this fifteen-year period is analytical in nature and mostly analyses historical systems. Examples include missile technological development (MacKenzie, 1987:189-216), telecommunications systems in the USA and Europe (Davies, 1996), history of the PVC industry (Mulder and Knot, 2001), the three ages of the French water industry (Barraqué, 2003), aluminium production systems in the Netherlands and Norway (Moores, 2006) and the American automobile industry (Shields, 2007). Research on emergent technological systems has also been gradually started up, for instance, in photovoltaic and wave power development (Christiansen and Buen, 2002), wireless telephone systems (Palen and Salzman, 2002), renewable energy technological systems (Tsoutsos and Stamboulis, 2005), electricity supply systems (Markard and Truffer, 2006) and the history of alternative fuels in transportation (Høyer, 2007).

Since then, further growth in the number and diversity of studies applying the reverse salients concept has become evident. From reviewing the trend, a notable number of studies analyse reverse salients in technological systems for sustainability. Beyond merely applying the concept at the analytical level, there is also a growing trend for studies to develop solutions to tackle reverse salients in terms of making recommendations and producing strategies and plans. Some expand the descriptive strength of the concept and make it into a methodological approach. That said, all analytical, pragmatic and methodological approaches of applying the reverse salients concept aim at solving critical problems to facilitate new systems growth. The visible growth of studies applying the reverse salients concept for analysing large technical systems and developing solutions for sustainability can be read to support this research targeting reverse salients to explore design for sustainability transitions. To affirm the benefit of using reverse salients concept in this research, a summarised account of this growing research body is provided below to show how the concept has been applied.

There are studies analysing a biogas system for vehicles in renewable fuel systems in Linköping, Sweden (Martin, 2009; Berglund et al., 2011). They analysed reverse salients in the course of biogas systems growth and then drew insights into overcoming barriers aiming to break through into the dominant non-renewable fuel systems. Another study determined the greatest reverse salients in hydrogen energy systems and made policy recommendations (Hugh, Roche and Bennett, 2007). In a similar manner, another study analysed and identified reverse salients in the new UK electricity network control systems and offered government recommendations (Lehtonen and Nye, 2009). A study analysing and comparing the biofuel systems in the US and Brazil explored the framing and articulation of reverse salients as partial solutions to solve ecological problems (Gee and McMeekin, 2011). A study of the low carbon electricity system in the UK analysed reverse salients into the window of opportunity for actors' sustainability choices in order to orient transitions pathways towards a low-carbon future (Foxon et al., 2013). Two studies targeting reverse salients in renewable energy systems and sustainable aquaculture systems respectively created strategic design solutions to mitigate the near-future worst situations in order to facilitate sustainability transitions[5] (Mok and Hyysalo, 2017; Mok and Gaziulusoy, 2018). Attempting to bring the reverse salients concept to a more complex level, a study analysed reverse salients not only within its own systems but amongst three systems for seamless coordination (Sawhney and Wang, 2009). The three systems under study are motor carriers, railroads and water carriers in an overall transportation system. From this meta-system perspective, as the study called it, reverse salients were identified to analyse a new approach to coordination. All of these represent diverse studies applying the concept of reverse salients.

Beyond creating solutions to solve critical problems for reverse salient removal, some studies expanded the concept to include a methodological approach. A study analysing hydrogen energy transitions developed a qualitative method to describe various depths of reverse salients (Hugh, Roche and Bennett, 2007). The method determined major obstacles impeding new systems and thereby concluded that more efforts need to put on those components to improve overall systems growth. In addition to a qualitative approach, some studies add a quantitative characteristic to the reverse salient concept (Dedehayir and Mäkinen, 2008; 2011; Daim et al., 2014). The quantifiable concept is applied to identify and forecast reverse salients through a method of performance gap measurement of reverse salients. The forecasting method was applied to tackle technological obstacles to realise the commercialisation of a new carbon nanotube biosensor technology (Han and Shin, 2014). Moreover, a study applying reverse salients as a methodology identified reverse salients in the development of electric vehicle (EV) systems and based on these reverse salients indicators suggested strategies for policy making (Wang, 2013).

Over three decades, the concept of reverse salients has been adopted for studying systems growth in large technical systems, as described in this summarised account. Furthermore, in the recent decade the concept has been gradually applied in the sustainability context to analyse problems impeding systems growth. In addition, practical solutions are also developed to practically tackle the identified reverse

[5] These two researches are the case studies of this doctoral research.

salients. The growing trend of applying the reverse salient concept for sustainability and its pragmatic effectiveness supports this research addressing reverse salients. Exploring in concert with this growing research body on reverse salients, the unique contribution of this research is to employ the reverse salients concept to explore a strategic design approach for sustainability. Strategic design is required due to the fact that reverse salients are problems that are not currently present but will develop in the near future. They need to be tackled because they will otherwise impede sustainability transitions. On the basis of the concept of reverse salients, this research explores strategic design for the short-term future that answers the unaddressed research area in the field of design for sustainability.

This section has interpreted and arranged three structural problems in socio-technical systems to bring out the concept of reverse salients. The table below lists the three problems – persistent, unforeseen and critical problems and their significances (Table 1. Characteristics of problems in socio-technical systems). In addition to investigating why transitions are often difficult and slow based on the theories, some design implications are becoming noticeable. The implications will be elaborated and organised for discussion in the section that follows.

Table 1. Characteristics of problems in socio-technical systems.

Characteristics	Main description
Problems are persistent	▪ socio-technical interdependencies interlock into the co-evolving processes that are embedded in systems, explaining the persistent nature of problems ▪ goal-seeking systems maintain a functional societal structure that develops path independencies and lock-ins in systems ▪ preconfigured systems environment favours the regime and resists niches ▪ resistance to changes from both dominant and new systems ▪ multiple value conflicts are inherent in systems ▪ multilevel perspective (MLP) aids transitions analysis and projections ▪ niche-regime inter-levels are contesting areas
Problems are unforeseen	▪ problems inherent in the short-term future emerge in unexpected future circumstances ▪ unexpected future circumstances restrain systems from advancing in goal-seeking systems ▪ the adverse results of reverse salients are not currently present but will develop in the short-term future ▪ elements in systems include both technical and societal elements ▪ problems in reverse salients can be reflected in contemporaneous occurrences with the transitions situations at present ▪ to improve systems growth, problems must be gradually overcome in ongoing, evolving transitions
Problems are critical	▪ mitigating reverse salients in systems transitions is a critical-problem-solving activity

	▪ reverse salients have to be defined as critical problems to be solved by working solutions ▪ an alternative and working solution to completely correct reverse salients ▪ transitions are long-term and non-linear processes; one cannot rely solely on pre-plans for the whole course of transitions or large-scale interventions

2.1.3 Insights into problems emerging in the short-term future

The previous section has explained three structural problems in socio-technical systems and the concept of reverse salients. The findings are synthesised to analyse key transitions insights into problems emerging in the short-term future. The insights aim at making implications for the design practice for sustainability. After analysis, three key transitions insights are drawn; they are discussed in the following part.

Transitions are involved in systems of interdependencies

Targeting problems in transitions requires the development of a systems perspective for transitions analysis. As stated, persistent problems are caused by the co-evolving processes of societal and technological development in systems. The co-evolving processes are underlain by strong transitions routines and lock-in mechanisms, from which emerge socio-technical interdependencies that are being interlocked in the processes. As a consequence, these interlocking relationships cause the persistence of problems in systems. They are structural in socio-technical systems, which makes shifting to new systems difficult and slow. These fundamental transitions concepts accentuate issues of sustainability transitions, such as strong resistance to changes and multiple conflicting values. These issues have to be comprehended and analysed in order to facilitate sustainability transitions.

For comprehending the high complexity of transitions dynamics in socio-technical systems, there must be comprehensive transitions analysis from a systems perspective. The MLP analytical framework conceptualises the concept of co-evolution in systems in a configuration. This configuration could be one useful tool to develop a systems perspective, in particular a multilevel perspective, for transitions analysis. The analytical framework analyses systems transitions through mapping numerous interferences of processes with interacting elements and activities lying in socio-technical systems within and between levels. In addition to its prospective strength, projecting transitions pathways of past and evolving transitions provides understanding of generic systems transitions patterns. The complex transitions configuration analyses alignment of activities and elements within the niche and regime, and amongst all levels in systems. The analysis would identify niche pathways to reveal situations that may have restrained transitions. While fathoming problems arising in the ongoing co-evolving processes, a window of opportunity can also be identified. An opportunity is created when at a contingent point where innovations are available from niches, internal tensions are created within regimes and pressure is exerted from the landscape. This opportunity contingent on the co-evolving processes between multiple levels enables the niche to break through the dominant regime. In addition, analysis of the alignment of the niche and regime offering from a multilevel perspective would also aid in scrutinising niche-regime inter-levels wherein the interlevel dynamic could be leveraged for changes. Leveraging niche-regime dynamics simultaneously alleviates resistance to changes from dominant systems and facilitates new systems growth.

Reverse salients are developing in the short-term future

To avoid adverse situations from developing in short-term future requires an understanding of reverse salients that may develop in near future to limit new systems development. The fact of future contingencies caused by societal and technological development co-evolving in systems in addition with internal and external dynamics in the transitions context forms indefinite transitions directions, from which unpredicted future circumstances in transitions emerge. These situations arising in the near future that may lead to undesirable outcomes are conceptualised as reverse salients. Due to the contingent nature of transitions, which results in unforeseen situations, the adverse effects of reverse salients are not currently present but will emerge in the short-term future. Hence, problems inherent in reverse salients have to be tackled because otherwise they form a poor quality of imbalanced growth of new systems, resulting in inferior development against the dominating systems. Due to the socio-technical interdependencies interlocking in systems, reverse salients are systems elements that implicate other systems elements, thereby crippling transitions. Having explained these, the problems inherent in reverse salients have to be diagnosed and analysed before they develop into adverse situations. This requires bringing forward visions of future situations to the forefront of transitions. Analysing reverse salients accentuates the criticality of problems and this implies what is needed in a solution. Moreover, it also determines the timing of interventions to orient transitions towards the targets before they lead to critical situations.

So far, the phrase short-term has been frequently used in this review discussion and it should be elaborated. Transitions scholars have theorised that the length of long systems transformation processes – from upsetting the current structure to stabilising the new one – is at least 25 years (Rotmans, Kemp and van Asselt, 2001). Recent research designing transitions pathways has also set the mid-range timeframe at 13 years (Hyysalo et al., 2019). The phrase short-term is hard to define in terms of how long of a period of time the future extends to. By implication, it can be understood as being the length of the range of time in which projections are possible. This implies that defining a range for which future situations can be projected based what is happening now might be workable to explain the short-term future. The abstraction of short-term future in this research is inspired by the theory of the zone of proximal development from the field of psychology, which illustrates distance between levels of learning potential (Vygotsky, 1978:79-91). When underpinned by the concept of reverse salients, the definition of short-term future can be attempted: "the future situations for which reverse salients can be projected" lie in the range between "the situations that are at present" and "the far future situations for which reverse salients cannot be projected" (Figure 3). This is how far ahead reverse salients can be projected, which also implies that reverse salients may be tackled when appropriate methods are available. Other phrases, such as *shorter-term, near future* or *near-term*, which are considered to carry similar meanings are occasionally used in this dissertation. Still, "short-term future" is the main phrase used throughout this dissertation.

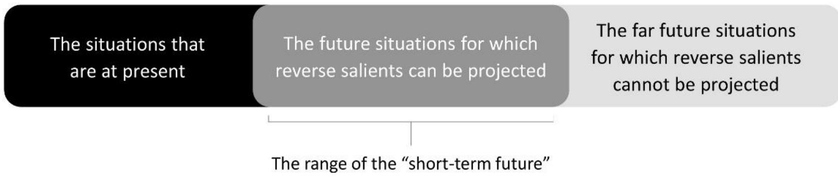

Figure 3. The range of the "short-term future" defined with the concept of reverse salients.

Reverse salients are corrigible

Targeting reverse salients requires mitigating predicted adverse conditions emerging in transitions. This urges early intervention, as they would otherwise lead to undesirable results that will hamper new systems growth. Hence, the concept of reverse salients by Hughes (1983:79-105) is associated with correction plans to set transitions right for new systems growth. This implies that reverse salients are corrigible.

Reverse salients are corrigible when the action of rectifying is conceptualised as a category of critical-problem-solving activity (Hughes, 1983:80). Reverse salients have to be defined as critical problems, implying that problems that would critically lead to adverse results can be corrected when solutions are offered. The solutions required are those that in the present solve problems inherent in the near future in order to mitigate adverse conditions from growing in the short-term future. This entails a strategic design for short-term future projections. Orientation of the transitions pathway is also due to the indefinite nature of transitions directions that require pre-plans for short-term planning. The interventions needed for systems transitions in the long transitions process, which covers at least 25 years, cannot be reliably pre-planned for the entire course of systems transitions. Rather, the long process requires pre-plans for short-term future projections at multiple timeframes in order to progressively overcome barriers in the ongoing evolving transitions. This has the advantage of orienting transitions pathways towards the long term. Equally important is an alternative and working solution to completely correct reverse salients, as otherwise new systems will not grow.

In addition, transitions pathways are also non-linear because they consist of fast and slow transitions dynamics. Hence, interventions need to be in varied scales from small to large to have an appropriate effect to orient pathways. This clarifies that even relatively modest efforts can contribute to an ongoing sustainability transition of a large-scale systems transition. The stress is placed on the practicality of the interventions to ensure a remarkable impact. Moreover, settling issues arising from the diverse interests of stakeholders also urges a solution that is a working compromise in equilibrium with conflicting values. This implies that a new solution which is simultaneously practical and optimal is desirable.

2.1.4 Transitions literature review summary

The above review of transitions literature in socio-technical systems and social studies of technology has enriched transitions insights into problems emerging in the short-term future in sustainability transitions – that is, reverse salients. To summarise the discussion, the first section (Section 2.2.1) gives a concise account of the fundamental concepts of transitions theories beginning from the root of the concept of socio-technical systems. The section investigates how a regime is formed and stabilised, and how systems transitions happen to enable a niche breakthrough to replace the dominant structure. The second section (Section 2.2.2) deepens the understanding of fundamental transition theories to analyse three key characteristics of problems in transitions – persistent, unforeseen and critical. Based on the three problem characteristics, the concept of reverse salients is also unfolded. The third section (Section 2.2.3) offers three key transitions insights into reverse salients, which provides implications concerning sustainability transitions for design practice. They study how to anticipate problems arising in the short-term future and indicate directions for design to mitigate them. The first insight is that transitions are involved in systems of interdependencies. Transitions analysis aids the analysis of both past and ongoing evolving transitions in specific situations as well as the prospect for future transitions pathways in order to identify contingent opportunities for a design intervention for a niche breakthrough. The second insight is that reverse salients are developing in the short-term future. This necessitates diagnosis and analysis of reverse salients. The third insight is that reverse salients are corrigible, which implies critical problem solving for practical and optimal solutions to overcoming problems inherent in the short-term future. Overall, targeting reverse salients demands timely diagnosis of reverse salients and early, alternative and practical solutions on any scale to remove reverse salients. Having explained the problems in transitions regarding reverse salients, what is needed is an operational strategic design for short-term future planning to tackle the issues – that is, a solution is required to practically solve problems before the adverse results materialise.

2.2. Strategic design from design management literature

In order to integrate knowledge to enhance design for sustainability at the systems level, the previous section of the transitions review has inquired into anticipating problems in the near future in systems transitions (Section 2.2). To continue the inquiry, this section reviews strategic design literature to investigate how strategic design actually works to implement actions in the short-term future to realise long-term futures. This strategic design review investigates the fundamental concepts of strategic design in corporate strategy to understand how strategic design is strategic in supporting corporate strategy. The review findings aid in the development of practical insights to guide strategic design to implement short-term future goals for sustainability transitions.

Studying strategic design in corporate strategy might appear to be at odds with the research focus on strategic design for sustainability: the former involves one's own self-interest in defining corporate goals as well as achieving business success, while the latter is in the interests of the common and greater environmental and social good, against one's self interest. However, this review strictly ensures that the findings will be contributive to sustainability by setting a clearly defined focus. This literature review focuses on exploring the operational elements from strategic design in corporate strategy for how to operationalise design to practically realise solutions for intended outcomes. Defining a strict focal study demarcates the exploration of operational elements of strategic design from the final objective of corporate strategy. In this way, the operational elements drawn will be lifted to the sustainability context to reconfigure strategic design for sustainability. Moreover, the sustainability agenda is well understood in corporate strategy, such as corporate social responsibility (CRS) and triple bottom line (TBL), where design plays a role in enhancing sustainability in organisations (studies, for example, McBride, 2011; Koo and Cooper, 2011). Again, this review places the operational elements of strategic design as the focal point of study to explore the effectiveness of their presence to achieve long-term intended outcomes without discriminating the sustainability aspects in corporate strategy. This clarification of the research focus is believed to avoid causing ambivalence in adopting strategic design from corporate strategy literature to gain insights into design for sustainability.

The focus of operational elements is supported by corporate strategy theory – strategic plans are strategic due to their intended course of actions and operational effectiveness to configure company resources as well as changes in environmental conditions in order to realise corporate goals (Ansoff, 1965; Porter, 1996; 1998 [1980]; Mintzberg, 1987; 1994). The corporate strategy theory clarifies the importance of the operational aspect of strategic design in supporting long-term visions. Based on the concept, operational elements refer to the elements of strategic design that have successfully enabled design activities to practically produce the intended results to fulfil short-term business targets towards achieving long-term corporate goals. Given this understanding, the exploration of the operational elements of strategic design would yield practical insights on strategic design in order to realise sustainability transitions.

Regarding strategic design, it has been used in corporate strategy to fulfil shorter-term business goals towards achieving longer-term corporate visions since the mid-1980s (Drucker, 1985). Since then, design has complemented the implementation of corporate strategy in which a supportive relationship between strategic design and corporate strategy has been established. To enhance design knowledge to achieve corporate strategy, it has been systematically studied in design management research for over three decades (Kim and Chung, 2007). The studies have explored different approaches to strategic design that have been used as means to achieve corporate goals. They have also provided abundant real company case studies, showcasing the comprehensive scope of design practice. On account of this rich body of scholarly study, reviewing strategic design from design management literature should render a detailed account of different ways in which strategic design has been used to implement corporate strategy. Moreover, based on the detailed account, the operational elements behind strategic design should be fathomed out for practical insights.

When design management literature is selected, it is with the awareness that a field of strategic design for sustainability exists. Indeed, this field of study has also been discussed in the introduction chapter (Chapter 1) to provide the reasoning behind the focus of this research. As discussed, most of these studies explored the development of strategic design at the strategic level for long-term planning (the studies include research by Ceschin, Gaziulusoy, Baek, Manzini and Meroni and so on). Different to them, this research focuses on developing strategic design for short-term future planning by scrutinising the operational elements of strategic design for practical insights. To achieve thorough scrutiny requires a comprehensive study of the wider scope of strategic design for varying their operational elements. Thus it makes sense to review strategic design from the broader design management literature. To conduct this strategic design review, relevant journal papers were located from key design management literature published in the period from 1971 to 2017. Papers were reviewed from four main journals: *Design Management Review, Design Management Journal, The Journal of Business Strategy* and *Harvard Business Review*. Additionally, books and personal conversations with several strategic design writers and designers about strategic design were also included (including Elmgreen who is the Senior Design Strategist of MindLab in Copenhagen, Denmark (Elmgreen, 2017) and Steinberg who was the Director of Strategic Design at Helsinki Design Lab, Finland (Steinberg, 2015)).

As stated above, there is a rich body of scholarly study in design management literature on discussion of strategic design in corporate strategy. These have tended to focus on studying different ways whereby design can achieve various corporate goals. However, the operational aspects of strategic design are still not discussed in much detail. It is necessary for this review to treat the operational elements of strategic design as the focal point for obtaining practical insights. Such examination of operational elements suggests a unique way of studying strategic design, which requires a systematic approach of review in phases. To build a systematic account, first, the relationship of strategic design and corporate strategy is reviewed to understand how strategic design implements corporate strategy at all strategy levels (Section 2.2.1). Second, different strategic design activities in corporate strategy are outlined to seek out their key operational elements that have made strategic design succeed in fulfilling shorter-term business goals for long-term corporate visions (Section 2.2.2). Third, the findings are synthesised to analyse key insights into operationalising strategic design solutions. The insights aid in developing strategic design for short-term future planning (Section 2.2.3). The last section is a review summary of strategic design (Section 2.2.4).

2.2.1 Strategic design and corporate strategy

This section explores the relationship of strategic design and corporate strategy to understand how strategic design implements corporate strategy at all strategy levels. Corporate strategy has been studied as a three-level structure since the mid-1960s (Ansoff, 1965). The three-level concept is adopted by subsequent corporate strategy theorists and writers, which has gradually established the fundamental framework for today's widely adopted three-level corporate strategy – corporate, business and operational levels (Johnson, Scholes and Whittington, 2008 [1993]; Joziasse, 2000). The three-level concept can be concisely summarised as follows. The corporate strategy level is concerned with a company's overall direction. The business level is about how to fulfil the specific goals of business units in order to support corporate visions. The operational level deals with ways to deliver efficiency and effectiveness in order to contribute to business-level goals through to corporate-level visions.

In correspondence, design management scholars have also discussed and formulated strategic design in the same three-level corporate strategy framework. Sometimes, the names of the three levels are used interchangeably with strategic, tactical and operational levels by some scholars. This review chooses to use the terms corporate, business and operational levels as they are more generally used in the field of design management. In spite of the different names, they all discuss the relationship of strategic design and corporate strategy in terms of how the two relate to each other. This has significance to understanding how strategic design functions at each strategy level to support overall corporate strategy. Major studies from design management scholars are presented below; they have been deliberately selected due to their distinctive perspectives on the relationship. Harnessing various perspectives on strategic design would widen the scope of study to offer richer insights into different concepts of strategic design relating to corporate strategy.

The early framework of strategic design in the corporate strategy setting by Rachael Cooper and Mike Press (1995) details three different sets of design activities that correspond to the three levels of corporate strategy. Their study adopts a competitive advantage perspective to study how design creates and maintains favourable conditions for a company to compete against its competitors through different design activities at each strategy level. The three levels of design activities are: developing corporate identity, designing saleable products and designing operating environments to achieve corporate strategy (Cooper and Press, 1995; Olson, Cooper and Slater, 1998). Each level of design activities is defined by particular operational functions in order to achieve specific business goals and corporate visions. In respect of the three levels, developing corporate identity interprets company values, designing saleable products creates company wealth and designing operating environments enhances company work processes.

This early strategic design framework by Cooper and Press is significant as it sets out the definition of how design operates at various corporate strategic levels to implement corporate strategy. Later, there are more studies from different perspectives which explore how design fulfils corporate strategy. For instance, Franz Joziasse (2000) also explores different design activities at the three corporate levels but from a design contribution perspective. He categorises strategic design based on the contribution that design has made to companies. At the strategic design level, design contributes to building competitive advantage and catalysing change. At the tactical level, design contributes to generating unique product concepts and services for new market opportunities and exploring future consumer needs. At the operational design level, design contributes to delivering efficiency and effectiveness of design projects.

Brigitte Borja de Mozota (2003; 2011, cited in Cooper, Junginger and Lockwood, 2011:276-293) studies strategic design from a value creation perspective. Her concept is adopted from Michael Porter's (1985) value chain model and focuses on the positioning of design throughout the value chain. In different positionings, design creates values to companies through different design activities, and in this way she categorises three design activities of the value chain: differentiation, coordination and transformation. Differentiation refers to value created through design activities of creating brand and customer values. Coordination applies to design activities of coordinating work processes among business units and functions. Transformation is about design activities to facilitate the structural change of the innovation process within the company as well as the external environment of the company in its industry.

Studying from the design role perspective, Kathryn Best (2006) classifies strategic design as having three different levels: design strategy, design process and design implementation. She explains that the different roles of design play on the three respective levels to effect corporate strategy. At the design strategy level, design plays the role of shaping corporate strategy through developing design initiatives. At the design process level, design plays the role of reinforcing corporate strategy through developing design plans and coordinating design projects of new product concepts. At this level, design also integrates other work processes to identify, build and leverage resources through comprehensive integration with different business units. At the design implementation level, design plays the role of achieving design outcomes through implementing design projects and enhancing work processes.

The above discussion on major studies has explained how strategic design supports corporate strategy. The studies have been deliberately selected such that each has its own distinctive perspective, which aims to offer a more comprehensive scope for understanding the relationship between strategic design and corporate strategy. The varied perspectives also give the relationship significances. To recap the discussion, Cooper and her associates take the perspective of competitive advantage to study how design creates and maintains a favourable condition for a company to compete against its competitors through specific design activities (Cooper and Press, 1995; Olson, Cooper and Slater, 1998). Joziasse (2000) offers a perspective on strategic design in terms of the different contributions made by different design activities to corporate strategy at the three levels. When viewed from the perspective of value creation, Borja de Mozota (2003; 2011, cited in Cooper, Junginger and Lockwood, 2011:276-293) categorises varied design activities in the value chain on the basis of their value added to companies. Best (2006) puts design roles into perspective to explain design performance and corporate strategy.

The varied perspectives shed light on two major significances in the relationship between strategic design and corporate strategy to explain how design is strategic in supporting the long-term corporate goals. First, the review analyses that there are always intended design activities to support a corresponding relationship between strategic design and corporate strategy regardless of the different perspectives on strategic design. These design activities are strategic, intending to practically achieve particular business goals at each corporate strategy level in order to achieve the long-term targets, which ultimately execute overall corporate strategy. The different design activities utilised in the discussed various perspectives are synthesised as follows: at the corporate strategy level, design supports strategy through creating and interpreting corporate values, developing corporate strategy and facilitating organisational changes to realise corporate visions. At the business strategy level, design fulfils the business-level goal of maintaining new design continuity and exploring new market opportunities, which maintains company growth and in the long term realises corporate visions. At the operational strategy level, design accomplishes operational-level goals to contribute to longer-term business-level and corporate-level visions through increasing design efficiency as well as operational efficiency of overall company work processes. The synthesised design activities are outlined in the table below (Table 2. Relationship of strategic design and corporate strategy – how corporate strategy is supported by different design activities corresponding to the three levels of corporate strategy).

Table 2. Relationship of strategic design and corporate strategy – how corporate strategy is supported by different design activities corresponding to the three levels of corporate strategy.

Three-level Corporate Strategy	Different design activities
Corporate level:	▪ To create and interpret corporate values ▪ To develop corporate strategy ▪ To facilitate organisation changes
Business level:	▪ To maintain new design continuity ▪ To explore new market opportunities
Operational level:	▪ To increase efficiency and effectiveness of design process ▪ To increase operational efficiency of work processes

Note: These concepts are adapted and synthesised from Cooper and Press, 1995; Olson, Cooper and Slater, 1998a; 1998b; Joziasse, 2000; Borja de Mozota, 2003; 2011, cited in Cooper, Junginger and Lockwood, 2011; Best, 2006.

The second significance of the intended design activities emerges from the first significance. This second significance lies in the operational effectiveness of design activities that practically function to achieve the intended outcomes. It is this operational characteristic that has made daily design activities successful in fulfilling short-term business targets to achieve long-term corporate goals and ultimately realise the overall strategy. It appears evident that for design to be operational does not mean that it cannot be strategic towards long-term goals. Similarly, for design to be strategic does not mean that it has no operational effectiveness at present. What is significant to strategic design is the need to develop strategic design solutions that have operational effectiveness in the shorter term in order to achieve longer-term targets. Having clarified the fact of the operational aspect of strategic design at all strategy levels, the following section examines different design activities to fathom out the operational elements behind strategic design.

2.2.2 The operational elements of strategic design

The above section has clarified the concept of the operational aspect of strategic design. It is now necessary to examine different design activities at each respective level. The examination intends to explore how different design activities work to fulfil the intended functions. In addition, it is important to seek out the operational elements of different design activities that have made strategic design succeed in achieving the long-term corporate visions.

The following reviews research that has studied real company cases for understanding different daily activities of strategic design at companies. In design management literature, there have been many case studies exploring design activities for specific research purposes. This section does not aim at presenting an exhaustive list of all design activities. Rather, it focuses on the key operational elements of the activities that have enabled strategic design to successfully produce the intended results and, furthermore, highlights those representative cases for focused discussions. The cases are extracted from 126 papers published in the period from 1971 to 2017 in the four main journals of design management literature that have been mentioned earlier. Additionally, books and personal conversations with several strategic design writers and designers about strategic design are also included.

The following is the discussion of different strategic design activities in corporate strategy having regard to their operational aspects. An outline is also presented in the table below (Table 3. Different strategic design activities in corporate strategy with regard to their operational aspects).

Table 3. Different strategic design activities in corporate strategy with regard to their operational aspects.

Three-level Corporate Strategy:	**Strategic design activities**	
Corporate level:	To create and interpret corporate values	▪ through setting corporate identity guidelines in tangible guidebooks and tangible product identity
	To develop corporate strategy	▪ through creating corporate visions to suggest new opportunities and probe information for formulating strategies, enhance communications for decision-making. Visions are produced in varied visual formats and specific visualisation quality in terms of legibility, clarity, comprehensibility and visibility
	To facilitate organisational changes	▪ through creating design visualisation with a tangible approach to provide detailed information on change plans to engage employees' discussions about changes ▪ through rendering emerging future company situations in high resolution and clarity to demonstrate the feasibility of change plans to prompt change actions from employees ▪ through presenting new design concepts in tangible prototypes and in realistic contexts to provide certainty about future changes to employees to reduce their resistance to newness
Business level:	To maintain new design continuity	▪ through initiating design plans to guide the launch of regular and future designs
	To explore new market opportunities	▪ through visualising future but working design concepts in real-life scenarios ▪ through rapidly prototyping new concepts in a real market context and within practical constraints
Operational level:	To increase efficiency and effectiveness of design process	▪ through visualising problems in concrete prototypes to clarify issues in the design process in order to enable employees to foresee issues ▪ through setting tangible product identity as a protocol to guide decision-making for efficiency
	To increase operational efficiency of work processes	▪ through guiding alternative ways of understanding problems, tolerating risks and failures, and learning about the corporate direction in a physical operating setting

Creating and interpreting corporate values

At the corporate level, design develops corporate identity that visually reflects company values (Cooper and Press, 1995). To guide interpretation of company values in a consistent manner, visual guidelines of corporate identity appearing in the form of corporate style guidebooks are produced. They are used to strictly guide all graphic communications connected to corporate values and strategy (Svengren Holm, 2011, cited in Cooper, Junginger and Lockwood, 2011:294-315). The IBM graphic standards manuals and Apple corporate identity guidelines provide two very clear examples of visual corporate guidelines. In particular, IBM developed an entire company identity manual that offered in-depth information on logotypes, fonts, documents, signage and packaging to other materials (Rand, 2014 [1947]). When interpreting corporate values, visual guidelines in concrete and tangible products are also used (Nussbaum, 2007; Camacho, 2016). A typical approach is to create product identity in distinctive design features on products to align product identity with corporate identity across both old and new design models. This reflects corporate values in a coherent way. When guided by product identity, the established corporate values can also be reflected in future product concepts that project new corporate visions (Montgomery, 2015; Lo, 2017). In this way, visual corporate guidelines function to both communicate company commitment to consumers and promote corporate values.

Developing corporate strategy

Design develops corporate strategy through creating future visions in visual forms (Joziasse, 2000; Yoo and Kim 2015). The future projections generated suggest new opportunities for companies to identify new ways forward. In a practical manner, Nokia developed corporate strategy by using scenarios to postulate future possibilities (Hiltunen, 2013). These scenarios of the new corporate strategy were generated based on detailed background analysis. They functioned to provide a basis for new corporate directions that might have future possibilities. They, on the one hand, tested new ideas of strategy for improvement and, on the other, probed for more information during the course of corporate strategic planning. Hence, these scenarios were strategic visions that assisted in formulating new corporate strategies. In this understanding, these scenarios clarifying future possibilities were not intended to show options for choice of new corporate directions but practically functioned for developing strategies (Brown, 2005; 2008). To successfully develop strategies, the quality of scenarios was in high clarity and great legibility in order to clarify necessary information to enable employees' further articulation regarding the changes.

To further complement the formulation of corporate strategy, companies move design to the forefront of corporate strategy to enable design to steward corporate decisions (Brown, 2005; Steinberg, 2015). When creating scenarios and visions, the format of visualisation is not limited to only drawing, but also includes varied forms such as physical and material prototypes. Besides formats, visualisation quality is also critical. Visualisation has to be legible in order to convey information and enhance communication to serve the executive board's decision making when developing corporate strategy (Svengren Holm, 2011, cited in Cooper, Junginger and Lockwood, 2011:294-315). In addition to legibility, high quality in terms of clarity, visibility and comprehensibility is also important for communicating details in corporate future visions (Brown, 2005).

Facilitating organisational changes

To facilitate organisational changes, strategic design is typically developed using a tangible approach. The way of facilitating organisational changes adopted by the German software company SAP is strategic design visualisation (Holloway, 2009). This type of visualisation using a tangible approach refers to visualising strategy that is not in the usual written form of change plans but is instead presented as physical and material prototypes. These prototypes are in high resolution and clarity to detail proposed changes, which are legible to clarify necessary information to be discussed by employees. They also provide a concrete means of tangibly engaging and interacting with employees. The tangible visualisation is generated based on analysis, such as statistical and technical analysis, or relevant detailed background analysis, which provides firm support to the proposed new strategy.

In another case, Hewlett-Packard (HP) rendered emerging future situations of the company and its broader market environment in high resolution and clarity, seeking to persuade its senior executives to realise the urgency of change (Sato et al., 2010). Clarifying this sense of urgency secured commitment from senior executives to engage in change efforts and as a result act in accordance with emerging market needs (Cooper and Press, 1995). In this understanding, design visualisation clarifying future situations is created to prompt actions from employees to achieve organisational changes (Brown, 2005; 2008).

In a different case, Samsung applied a tangible approach to provide certainty regarding the company's new design concepts in order to gain employees' confidence. Tangible mock-ups and prototypes were used in the design process to demonstrate the feasibility of future concepts in concrete terms. This improved the risk-averse company culture of Samsung, which has often resisted newness (Yoo and Kim, 2015). In situations in which it is difficult to shift more persistent attitudes, tangible prototypes are suggested to be presented in a realistic context to further demonstrate the need to make urgent changes to employees in a tangible way (Camacho, 2016).

Maintaining new design continuity

At the business strategy level, design maintains design continuity through initiating overall design plans to guide the launch of new products and services (Verganti, 2009). To ensure new model continuity in operation, car companies regularly launch new cars to fulfil current market needs in addition to future car concepts to show at motor car shows with the aim of building strategic prospects for consumers. Maintaining design continuity also communicates a future commitment to consumers that the company bears a responsibility to achieve, which ultimately guides the company forward towards its corporate visions (Montgomery, 2015). To meet existing market needs and gain market leadership, innovative products and services with superior quality must be created to reinforce corporate competitiveness in the long term (Person, Snelders and Schoormans, 2012).

Exploring new market opportunities

To explore new concepts and future consumer needs for new market opportunities, Philips has conducted future research since the mid-1990s (Philips Corporate Design, 1996; Lambourne, Feiz and Rigot, 1997). The research was conducted through demonstrating future but working design concepts to consumers in real-life scenarios. For instance, in the late 1990s, short films were made to project Philips' new design theme of the Vision of the Future. The exploration was done by showing the daily life of users interacting with future products. This helped clarify that Philips' future vision was not science fiction but the development of products in everyday life towards possible future living. Similarly, PepsiCo explored future consumer needs by rapidly prototyping new ideas in a real market context, which accelerated the process of new concept exploration (de Vries, 2015). The realistic context guides innovative concept exploration within practical considerations and constraints, helping clarify the feasibility of new concepts (Design Council, 2015).

Increasing efficiency and effectiveness of design process

At the operational strategy level, it is important to increase the efficiency and effectiveness of the design process in order to deliver design outcomes to execute strategy. In a design process, manufacturing constraints and costs concerns are typical issues that often cause problems that impede the design process. To mitigate possible problems from arising, prototypes produced in superior and aesthetic quality that look concrete and real are used not only as aesthetic models, but also as functional models to visualise future business growth and reveal challenges in how to realise the new concepts when they are put into practice. This approach is particularly applied by car companies, which produce detailed concrete car models, from clay models to concept cars, to guide employees to foresee production challenges and issues before actual mass manufacturing (Holloway, 2009). The concreteness and realness of prototypes guide discussion about practical manners, which enhances problem solving for design efficiency. In order to bring forward problems to enhance discussion, prototypes are usually created in high visualisation quality – well-defined, clear, precise and real (Brown, 2005; Design Council, 2015; Yoo and Kim, 2015).

PepsiCo also used a prototyping process to tangibly reveal issues that are usually invisible in the abstract (de Vries, 2015). To improve early intervention, Danish companies use design in early stages of innovation development (Danish

Design Centre, 2016; Camacho, 2016; Elmgreen, 2017). A similar positioning approach is to position design across company levels to attain an overall outlook for the company and its industrial environment (Best, 2006).

For work efficiency, instead of being used to benchmark overall corporate identity as a design strategy, product identity is used to guide the design process as a protocol. In this way, product identity in distinctive design features that reflect corporate values and strategy are applied as established protocol. The protocol guides reaching a consensus view among different work units, and additionally guides decision-making in accordance with corporate directions for business efficiency (Lo, 2017).

Increasing operational efficiency of work processes

In addition to enhancing design process efficiency, design is also used to increase the efficiency of overall operation of companies to implement corporate strategy. To fulfil this purpose, the operating environment of a company is designed and organised in a way to enhance work processes in that company (Cooper and Press, 1995). An operating environment organised by design usually incorporates an innovation setting that nurtures an innovation culture. This fosters alternative ways of understanding problems and also results in making fast decisions and encouraging effective actions from employees (IBM, 2010). Such a corporate culture also prepares individuals to tolerate risk and failure and as such has practical functions (PriceWaterhouseCoopers, 2009). In addition, a deliberately designed physical environment aligning with corporate strategy would guide employee learning of corporate directions (Svengren Holm, 2011, cited in Cooper, Junginger and Lockwood, 2011). This grows a consensus of employees' understanding on corporate strategy towards long-term corporate visions for increasing work efficiency.

In brief, design increases the operational efficiency and effectiveness of overall company work processes through guiding alternative ways of understanding problems, tolerating risks and failures, and learning of corporate strategy. These are achieved by designing and organising a physical operating setting.

To summarise this section, it has examined a diverse range of design activities functioning at all three strategy levels to achieve corporate strategy. This aims at describing the operational aspects of strategic design in terms of their operational manners and operational elements. Regarding operational manners, ways of setting guidelines, visualising future working concepts, demonstrating the feasibility of changes and newness, clarifying issues of new strategy, developing and achieving plans and strategies, visualising possible problems in predicted occurrences, rapid prototyping in a real context tends to be extensively used. Moreover, some common elements can be identified amongst these approaches, such as visual formats and visualisation quality that requires tangibility, legibility, clarity, comprehensibility, visibility and concreteness. These findings are further analysed to investigate how to create strategic design solutions that have operational effectiveness to achieve the intended outcomes.

2.2.3 Insights into short-term future planning

After outlining different design activities in corporate strategy in wide scope, this section discusses the operational aspects of strategic design in further detail. The different design activities are synthesised to analyse key insights into creating operational strategic design solutions. The following describes two key insights.

Strategic designs are instructive

Operational strategic design has to be instructive because it has to guide the intended actions to fulfil business goals in the shorter term in order to achieve corporate visions in the long term. Furthermore, to ensure to achievement of the intended outcomes, guidelines have to be set in clear and concrete forms.

Design has been used to develop corporate identity that visually reflects company values wherein the values should align with corporate strategy (Cooper and Press, 1995). In order to communicate company identity in a consistent way that reflects uniform company values as well as in a coherent way that connects the values to corporate strategy, designers have built skills in developing guidelines and setting them in visual forms (Svengren Holm, 2011, cited in Cooper, Junginger and Lockwood, 2011:294-315). A typical design guideline is the comprehensive corporate identity guidelines that are developed and set in the visual form of style guidebooks. The guidebooks are delivered in high resolution, containing comprehensive information. The information is clearly defined to precisely guide all graphic communications concerning corporate identity to ensure coherence. The clarity and tangibility of the guidelines have been proven to achieve the intended result of guiding the interpretation of corporate values. In this example, the style guidebooks are developed to govern the intended action of communicating corporate values in a consistent and coherent way. To ensure the intended outcome instead of resulting in other undesirable outcomes, the guidelines are created in visual forms in a quality of clarity, high resolution, tangibility and intelligibility.

Another example of developing and setting guidelines is the development of a product identity to guide the design process. The product identity is set in a visual form of distinctive design features, which are applied to tangible products to distinguish the design from competitors, wherein the distinctiveness has to be consistent to align all design models. These visually and tangibly expressed design features are concrete and clearly defined to strictly align all product design across old and new design models. In this way, the consistent product identity guides the coherent interpretation of corporate values. In this example, product identity is developed to govern the intended action of designing products to ensure that all models are consistent with both each other and the corporate identity. In another way, product identity is also developed but used for a different purpose, which is applied to guide decision-making in the design process to enhance work efficiency. To achieve this, the distinctive and consistent design features on products that are governed by product identity are applied as an established protocol in the design process. This visual format of protocol enhances reaching a consensus view amongst different work units and, additionally, guides decision-making in accordance with corporate directions. In this way, strategically developing the product identity and laying it as guidelines in the form of tangible product design features tend to achieve the required outcome of increasing work efficiency in the design process. Both examples use product design as guidelines for their intended outcomes – the former consistently aligns all design models and the latter strictly guides decision-making for work efficiency. To ensure their intended outcomes, the guidelines of product identity are set in visual forms in terms of concreteness, tangibility and precision.

In addition, design develops overall design plans to guide the launch of regular and future designs to maintain new design continuity. The design plans are also visualised in tangible forms to be shown in the market. For example, new and regular cars together with future concept cars are launched at motor car shows to present companies' strategic prospects to customers. In this way, establishing continuity of new design and showcasing it in visible forms represents the company's commitment to consumers; efforts to deliver on this commitment guide the company forward towards achieving long-term corporate goals.

Moreover, prototypes of a superior quality not only reflect company values but also serve to guide technical discussion on future production challenges and issues before actual mass manufacturing. This is because the prototypes are produced in precise and detailed quality that exposes the challenges involved in how to put the concepts into practice for realisation. In this way, the prototypes are useful and informative in aiding employees to foresee problems in the design process. As a result, this increases the efficiency and effectiveness of the process. The concreteness and realness of prototypes enhances discussion about practical manners for early problem solving. Overall, setting guidelines aims at governing the intended actions to achieve the intended outcomes instead of other undesirable outcomes. To ensure achieving the intended outcomes, guidelines are strategically set in visual forms with a specific visualisation quality.

Strategic designs are working solutions

Strategic design offers working solutions because the solutions, though they are often new and future-oriented, have to be feasible and achievable to fulfil the present goals towards attaining longer-term corporate visions.

Due to the fact of resistance to newness, design has been grounded in the skills and practices to prove the future and practical feasibility of future design concepts.

This has been seen in the recent case study of Samsung, which shows that the company culture has often resisted newness (Yoo and Kim, 2015), and as early as in the mid-1990s Philips had to offer working concepts to prove future design concepts (Lambourne, Feiz and Rigot, 1997). To support the feasibility of new concepts, design has to give careful consideration to the rationales behind the new and future design. Equally as important, the rationales behind the future design concepts have to be demonstrated in order to effectively reduce resistance to newness from other work units.

In the design process, abstract new concepts are presented in tangible means in order to demonstrate that the concepts are not abstract at all. The physical existence and material form of prototypes aids the concretisation of those abstract concepts. In a tangible approach, prototypes are also presented in full size and in a realistic context. Realness in terms of size and real-life environment proves that new design concepts are developed and proposed within practical considerations for feasibility. As a result, demonstrating feasibility enhances the workability of new concepts, which ensures the intended outcome of reducing resistance to new concepts. Regarding new concepts, scenarios are also used to demonstrate the feasibility of future visions for exploring new market opportunities. The scenarios show that practical feasibility enhances interaction with users and evokes further elaboration from them, thereby helping explore new market opportunities. These scenarios – which may be presented in the form of short videos, for example – demonstrate the practical feasibility of new concepts by showing future product concepts in a realistic context based on present circumstances and with practical considerations. Showing feasibility emphasises that the strategic visions are actual and genuine, used for real and practical functions.

In addition to new design concepts, the feasibility of company change directions is also presented using a tangible approach. The tangible approach adopts physical and material prototypes instead of the usual written format. The high resolution of prototypes contains a large quantity of information with details about changes and newness. Such informative and communicable visualisation enables employees to deliberate over issues that will be important in the future. This aids in achieving the intended outcome of enhancing employees' engagement in company change plans, and thereby spurs them to take change actions in response to the change directions of the company. With respect to the quality of tangibility, prototypes detailing the proposed changes clarify desirable future situations and explain the reasons for the change directions. They are intended to facilitate organisational changes through demonstrating the practical feasibility of new directions. Moreover, the concrete visualisation enables employees to act without misconceptions towards change targets.

Another way of showing feasibility is to postulate future possibilities in scenarios. The scenarios provide a basis for new corporate strategy that might have future possibilities. These scenarios are generated based on analysis, such as statistical and technical analysis, or relevant detailed background analysis, which supports the proposed strategy. The quality of these scenarios is in high clarity in terms of great legibility and comprehensibility in order to encourage discussions about new ideas for strategies as well as probe more information from employees in the course of strategy planning. The quality of visualisation also makes the future more visible and comprehensible because strategy that is tangibly visualised is enhanced to be seen, noticed and experienced. This visibility has an effect and impact to spur future-oriented analysis of strategy among employees, while the legibility enables employees to further articulate improvements to the strategy. In this way, a well-defined and precise visualisation projecting into the future is critical, as the visualisation is not intended to show options for selection but to serve as a practical means of improving strategy planning. The visual formats are varied, including design drawings, scenarios, videos, films, models and prototypes.

2.2.4 Strategic design literature review summary

To make a summary of this strategic design review based on the design management literature, the first section (Section 2.2.1) exploring the relationship between strategic design and corporate strategy has revealed two major findings regarding strategic design – the intended design activities and the operational elements of strategic design. Regarding the former, it is the importance of the operational aspect of strategic design that has enabled design activities to succeed in practically providing the intended results to fulfil short-term business targets towards achieving long-term corporate goals. The finding that for design to be operational does not mean that it cannot be strategic towards long-term goals appears to be evident. Similarly, for design to be strategic does not mean that it has no operational effectiveness at present. By implication, a strategic design that does not take the operational aspect into consideration is not strategic.

Having drawn the relationship between strategic design and corporate strategy, more review efforts are necessary to unveil the operational aspects of strategic design for significant practical insights. The second section (Section 2.2.2) scrutinises different strategic design activities to seek out the operational approaches and operational elements of strategic design. Afterwards, the findings are synthesised to develop practical insights to guide strategic design for sustainability transitions. The last section (Section 2.2.3) draws two key insights into creating operational strategic design for achieving the intended outcomes in the short term, which aims at realising long-term visions. The two key insights are that strategic designs are instructive and strategic designs are working solutions. These two strategic design insights will be integrated with transitions insights for developing strategic design for sustainability transitions targeting the mitigation of reverse salients in transitions.

2.3. An initial design approach to strategic design for the short-term future

The literature review has sought to explain systems transitions for sustainability and has yielded insights into addressing reverse salients. The transitions review investigating how to anticipate reverse salients offers three transitions insights: (1) transitions are involved in systems of interdependencies, (2) reverse salients are developing in the short-term future and (3) reverse salients are corrigible. The strategic design review investigating how to develop and operationalise short-term future planning to mitigate possibly developing reverse salients yields two strategic design insights: (1) strategic designs are instructive and (2) strategic designs are working solutions. Taken together, the two sets of insights would enrich understanding to create strategic design solutions to deal with reverse salients. When forming this new design approach by integrating transitions and strategic design insights, it is assumed that adopting the approach would enhance design to develop strategic design to mitigate reverse salients for sustainability transitions. To ensure relevance for design practice, the insights are reinforced with suggestive ideas to provide more actionable indications. This develops design implications for implementing a design process to create strategic design that tackles reverse salients.

2.3.1 Design implications developing from transitions insights and strategic design insights

To yield design implications that are suggestive for design practice to anticipate and mitigate reverse salients, the five key insights are reviewed. In the process of developing design implications, the insights are probed in terms of their unique roles to anticipate and overcome problems in the short-term future. Each of these sets their scopes and the corresponding activities needed to fulfil the roles. The developed design implications would lay a foundation for implementing a design process to create strategic design for reverse salients. Based on the parameters of each role and their activities, five design implications are made and the discussion follows.

Analysing transitions from a multilevel perspective

The transitions insight of “transitions are involved in systems of interdependencies” discusses the role of analysing transitions from a multiple-level systems perspective. Based on transitions theories, transitions are involved in systems of socio-technical interdependencies. The complexity of interdependencies requires building a multiple-level perspective in order to comprehensively understand specific transitions situations. A multilevel perspective is a systems perspective whose name especially highlights the myriads of processes co-evolving amongst multiple levels in socio-technical systems. The perspective enables explaining not only the transitions situation alone but also its interrelationships within its systems. The role of analysing transitions from a multilevel perspective sets the scope to complete a conceptual analysis of a specific transitions situation in its systems.

When adopting a multilevel perspective, analytical tools are suggested to aid comprehension of transitions; one such tool is the MLP analytical framework from transitions studies. Other models, approaches, frameworks and tools are also appropriate for building a systems perspective and they should be also adopted. Aided by an analytical framework, typically MLP, all elements comprising both societal and technological elements should be mapped on the configuration for analysis. The MLP framework provides comprehensive multilevel transitions analysis and is used in two aspects – the analytical and prospective aspects. In its analytical strength, MLP maps the co-evolutionary transitions dynamics in systems from a multilevel perspective and thereby facilitates the explanation of past and ongoing transitions in specific situations in their systems. Transitions dynamics refer to the numerous interferences of processes within and amongst multi-levels in socio-technical systems. In this way, the configuration of the processes explains the past and ongoing transitions. The configuration could then be used to analyse the alignment of processes to elaborate future transitions projections in a particular transitions situation for niche pathways. In this prospective aspect, the trajectories indicate future transitions projections that set strategic directions for niche development to break through the regime. When at a contingent point where innovations are available from the niche, pressure from the landscape is exerted on the regime and internal tensions are increased within the regime, a window of opportunity can be created for a niche breakthrough. The window of time for taking advantage to achieve a desired outcome is relatively short and must be seized promptly. In this interface, design should seek a contingent opportunity to initiate a deliberate intervention to tackle reverse salients.

At the same time, examining niche pathways may reveal uneven growth quality of the niche. Understanding the uneven growth quality of the niche is of crucial importance; without deliberate orientation, reverse salients arising in transitions dynamics will impede niche growth and hamper overall transitions. It is suggested that favourable conditions be developed as a means of niche tactical engagement to set the transitions right. Moreover, studying from a multilevel perspective enables design to inspect niche-regime inter-levels to investigate opportunities by leveraging interlevel dynamics for changes. When leveraging interlevel dynamics, the concept of transferability could also be applied, aiding design to align systems elements in the regime and niche to produce a systems transition.

Identifying reverse salients

The second insight of "reverse salients are developing in the short-term future" defines the role of identifying reverse salients before adverse situations develop. As learned from transitions theories, reverse salients arise in the short-term future due to future contingencies of socio-technical development co-evolving in systems, additionally influenced by external dynamics. Adverse results caused by reverse salients are usually not in effect yet at present but may arise in the near future. Hence, reverse salients have to be anticipated and handled with solutions offered to avoid undesirable outcomes.

The role of identifying reverse salients confines the scope to finding major reverse salients. To play the role of anticipating reverse salients that are not issues at present but will arise in short term in transitions dynamics demands particular activities. Before stating the activities in scope, some defining characteristics of reverse salients may be helpful to provide a basis for identifying them. Reverse salients are implied by (i) interdependent systems elements interlocking in socio-technical systems interdependencies; (ii) any type of elements in systems including both technical and societal elements; (iii) underperforming systems elements in the frontline of new systems that are not advancing together with others; they are (iv) developing in transitions dynamics in the future during the course of the systems growth process, which thus need to be gradually overcome; (v) their adverse effects are not currently present but will arise in the short-term future; and (vi) usually unforeseen, but are difficult to tackle even if they are foreseen. These six characteristics offer a basis to identify reverse salients.

As indicated by these six reverse salients characteristics, two main steps can be suggested to anticipate them. The two main steps are diagnosis and analysis of reverse salients. The interdependent nature of reverse salients explains the fact that no single element can be isolated in systems due to the interconnectedness of systems. However, this also offers a way to approach unforeseen reverse salients. Regarding the first step, reverse salients can be reflected by contemporaneous occurrences in specific transitions situations and based on the related issues it can be diagnosed which issues constitute reverse salients and which ones are major. Recalling Hughes' study on the new electricity system, the storage batteries, two-wire feeder-and-main system and the patent application for a three-wire system all constitute reverse salients of high electricity distribution costs (Hughes, 1983:79-105). They are all related issues in the development of reverse salients that would cause new electricity systems to fail in developing a new market for the new electricity system. In other words, without reducing the high costs of long-distance transmission, the new systems would not have a market.

The second step is to analyse reverse salients. Analysis of reverse salients is carried out to decide which issues constitute major reverse salients that would to a great degree impede overall new systems growth and thus need to be solved. The analysis of reverse saliency would then identify solutions for reverse salients removal. Returning to Hughes' study, it was only when the radical solution of the alternating current system was implemented that the reverse salients of high distribution costs could be eventually corrected. Analysis of reverse salients to reveal the criticality of problems on the one hand determines the goals of solutions, and on the other also determines the timing of interventions to be taken before other inferior measures intervene. In the new electricity case, the critical reverse salient of high costs had to be tackled by realising an alternative solution comprising an alternating current system before the less desirable two-wire system went into regular operation in two months. Some studies have developed methodological approaches to assist in the analysis of reverse saliency. They include qualitative methods to describe different depths of reverse salients and quantitative methods to measure their performance gaps.

Correcting reverse salients

"Reverse salients are corrigible," as stated by the key transitions insight, which literally suggests the role of correcting reverse salients. The concept of reverse salients is associated with correction plans and this planning requires the definition of major reverse salients as critical problems for correction. This makes sense of placing reverse salients on target as one investigation to orient transitions pathways for correction plans. To fully correct reverse salients, the solutions needed are advised to be alternative, as in the new electricity systems example wherein the alternating current system represents an alternative solution to fully correct the reverse salient of high distribution costs.

The role of correcting reverse salients sets the scope to initiate alternative solutions. First of all, in order to initiate solutions, reverse salients must be defined as critical problems; the process has come to be called "critical-problem-solving activity." Afterwards, new solutions are required to practically solve critical problems. There are several implications of developing an alternative solution for solving critical problems. First, to pre-empt undesirable situations from happening, a practical solution is crucial. To cause the intended effects, the goals of these practical solutions have to be determined. As discussed earlier, the diagnosis of reverse salients that reveals the criticality of problems would have determined the goals of the necessary new solutions. Second, to effectively pre-empt reverse salients implies the need for pre-plans for shorter-term planning. This is because, fundamentally, transitions require progressive interventions to gradually overcome barriers in the long process of ongoing evolving transitions due to the fact that the socio-technical environment is preconfigured to favour the regime. The progressive interventions needed for sustainability transitions cannot be reliably pre-planned for the entire course of systems transitions, but are instead pre-planned for short-term future projections and on multiple time frames. Furthermore, the solution has to be operationalised before reverse salients develop. For this, the diagnosis of reverse salients has also determined that interventions must be timed to occur before other less undesirable measures intervene. Third, an alternative solution providing available possibilities also urges a solution that is a working compromise in equilibrium between the conflicting values. This adds practical and optimal dimensions to the strategic design solution. To attain an equilibrium, the development of the solution has to investigate multiple values implicated in the transitions situation. Last, due to the non-linear transitions paths, the scales of interventions can be varied from small to large whenever appropriate for orienting transitions. This clarifies that even relatively modest efforts can contribute to an ongoing sustainability transition in a large-scale systems transition.

Setting guidelines for actions

The strategic design review has given insights into how to operationalise strategic design. One of the key insights is that "strategic designs are instructive". For strategic designs to be instructive, guidelines have to be offered in the solutions, which defines the role of setting guidelines for actions to fulfil the intended outcomes. Importantly, the guided actions have to be taken at present in order to prevent disastrous results from arising. The role has to complete a strategic guideline. To do so, guidelines are developed under certain criteria and in specific ways.

To mitigate reverse salients, first, guidelines are set to guide actions that are to be taken at the present time. Second, the expected actions have to align with the intended outcomes in the short-term future in order to achieve far-future visions. These two criteria have understood that the actions taken at present have to be effective for the future. In this light, the first activity of setting guidelines for actions is to align actions at present with mid-term and long-term sustainability targets. Corporate strategy utilises the development of corporate style guidebooks to guide graphic communications in order to fulfil the intended result of interpreting corporate values. Also, product identity is developed to guide new design continuity in order to achieve design coherence across old and new design models as well as the interpretation of corporate values in a coherent way. To increase commitment of the solutions to realising changes and the urgency to change, guidelines are suggested to be visualised in visual and tangible forms. This defines the second activity of setting guidelines for actions to visualise guidelines in varied visual forms. Strategy visualisations that are not in the usual written form of change plans but instead employ a tangible approach provide concrete forms to tangibly engage and interact with stakeholders. This makes future changes more visible to stakeholders. When the solutions are visualised to be seen, noticed and experienced, this increases the visibility, intelligibility and comprehensibility of the solutions. Furthermore, this visibility aids in clarifying strategic prospects to stakeholders. The visualisation of plans also increases the realness of new solutions, as it grounds them to its connection to reality. This increases the commitment of the solutions to realising changes and, furthermore, realising an urgency to change. The different visual formats used vary from design drawings to scenarios, videos, films, models and prototypes.

When guidelines are set in visual and tangible forms, they also fulfil a specific visualisation quality. The quality of visualisation increases the operational effectiveness of strategic design solutions to strengthen the intended outcomes. This suggests another activity of setting guidelines for actions to develop clear and concrete guidelines in order to govern the intended actions for desirable outcomes instead of other unintended actions. The information contained in the guidelines has to be clearly defined so that all actions strictly follow the guidelines. For example, distinctive design features visualised on products serve as a concrete protocol to guide design decisions in design processes for business efficiency. In addition, when guidelines are used to guide discussions on future challenges and short-term issues, prototypes of a superior quality are applied. The prototypes serve guiding functions because they are produced in precise and detailed quality, exposing challenges in how to put the concepts into practice for realisation.

Demonstrating the feasibility of the solutions

The insight of "strategic designs are working solutions" implies the role of demonstrating the feasibility of the solutions. As discussed above regarding the need for alternative solutions to mitigate reverse salients, however, initiating alternative solutions would easily encounter resistance to newness. To reduce resistance, the feasibility of solutions has to be demonstrated in order to overcome scepticism. The role of demonstrating the feasibility of the solutions sets the scope of the task to provide rationales behind the working solutions.

To support the feasibility of new concepts, the new abstract concepts have to be concretised. It is suggested that they must be considered carefully and the rationales behind the strategic design solutions have to be given in order to effectively reduce resistance to newness from stakeholders. To do so, the first activity involves generating design solutions based on analysis, such as statistical and technical, or relevant detailed background analysis. The feasibility of the future concepts is also suggested to be based on present circumstances. These demonstrate that practicality is taken into consideration and, additionally, supports analysis in broad aspects. In this way, determining feasibility proves that the future new concepts are actual and genuine, possessing real and practical functions.

Having addressed practical considerations and viability analysis, the feasibility of solutions has to be shown for the soundness of solutions. This involves the second activity of visualising the rationales behind the alternative solutions. To demonstrate and prove the viability of the solutions, it is advised to visualise the rationales in tangible means. These tangible means could take the physical and material form of prototypes, for instance. In particular, the solutions should be shown in full size and in a real-life context to demonstrate their relevancy to real situations. To engage users and evoke further elaboration from them, showing practical feasibility is particularly essential. It is equally important to engage employees to facilitate their own change plans towards achieving targets. In order to prompt actions, the visualisation has to explain the changes and newness in detail. This informs employees and communicates with them to clarify the desirable change situations and explains the reasons for the necessary changes. In addition, feasibility has to be visualised in high clarity in terms of legibility and comprehensibility in order to evoke discussions about the strategic ideas behind the strategies.

The five design implications developed from transitions insights and strategic design insights have been discussed to investigate their unique roles in the creation of strategic design solutions for short-term future planning to mitigate reverse salients. Their unique roles set the scopes and specific activities. The table below lists the five theoretical insights obtained from the transitions and strategic design review and the design implications developed from the five insights. The table also classifies and describes the role, scope and activities (Table 4. Developing transitions insights and strategic design insights into design implications).

Table 4. Developing transitions insights and strategic design insights into design implications.

Theoretical insights	Design implications	
Transitions insights	**roles**	**activities**
▪ Transitions are involved in systems of interdependencies	▪ Analysing transitions from a multilevel perspective	▪ adopting a systems perspective, typically a multiple-level perspective ▪ analysing alignment of processes within and amongst levels in systems ▪ analysing niche pathways that may reveal uneven niche growth in systems
▪ Reverse salients are developing in the short-term future	▪ Identifying reverse salients	▪ diagnosing reverse salients by reflecting on contemporaneous occurrences ▪ analysing major reverse salients
▪ Reverse salients are corrigible	▪ Correcting reverse salients	▪ defining goals of solutions ▪ considering timing for short-term future planning ▪ seeking stakeholder tactical engagement site
Strategic design insights	**roles**	**activities**
▪ Strategic designs are instructive	▪ Setting guidelines for actions	▪ aligning short-term actions with mid-term and long-term sustainability targets ▪ developing clear and concrete guidelines ▪ visualising guidelines in visual forms
▪ Strategic designs are working solutions	▪ Demonstrating feasibility of the solutions	▪ conducting analysis for practical considerations and ensuring viability ▪ visualising the rationales behind the solutions in tangible means

2.3.2 Forming into an initial design approach

The above has discussed the unique roles implied by transitions insights and strategic design insights. The specific roles clearly define and limit each scope to a devoted task that is sufficient to fulfil the roles. On the one hand, each of the roles has its different scope and activities. The activities that fall within each scope are also specific without overlapping amongst them. On the other hand, when the insights are brought together, connections between transitions and strategic design insights become visible. This is likely to lay a foundation for implementing a design process to create strategic design for reverse salients. This section explores the dynamics amongst them when they work together to support the creation of strategic design solutions.

The three transitions insights define the three respective roles of strategic design of analysing transitions from a multilevel perspective, identifying reverse salients arising in transitions and correcting reverse salients. Each of these seeks to complete the tasks within their own scopes aiming at anticipating reverse salients. The two strategic design insights define the roles of strategic design in setting guidelines for actions and demonstrating feasibility of the solutions accordingly. Each involves their own activities for the tasks to be completed in order to operationalise strategic design plans for reverse salients. Despite their unique roles, the transitions insights and strategic design insights are closely connected. They connect together to guide strategic design to mitigate reverse salients. Connections are revealed not only between the two sets of theoretical insights, but also amongst the insights. For instance, analysis of reverse salients determines the goals of solutions and timing of interventions (developed from the insight of "reverse salients are developing in the short-term future") for correcting reverse salients (developed from the insight of "reverse salients are corrigible"). Seeking for space and timing to initiate alternative solutions to correct reverse salients requires analysis of alignment of processes in systems in order to identify opportunities for a niche breakthrough (developed from the insight of "transitions are involved in systems of interdependencies"). Achieving the intended outcomes of the alternative solutions (developed from the insight of "reverse salients are corrigible") also identifies the setting of a strategic guideline (developed from the insight of "strategic designs are instructive"). To support the expected actions, the solutions have to be justified by demonstrating the feasibility of the solutions (developed from the insight of "strategic designs are working solutions"). These connections explain the dynamic nature of the interrelationships between transitions insights and strategic design insights and amongst each insight.

Not only are they connected, when the five theoretical insights are arranged together, they tend to choreograph a process beginning from analysing the transitions situation through to mitigating the reverse salients. When referring to Table 4 above, the listed activities suggested from each insight seem to lay out a procedure to support strategic design to develop short-term future planning to mitigate reverse salients. An attempt to narrate the procedure follows. The first transitions insight requires analysing transitions from a multilevel perspective. The procedure begins by adopting a systems perspective for analysis, typically a multiple-level perspective. The MLP framework mapping systems elements analyses alignment of processes within and amongst multi-levels for transitions projections to identify opportunities for a niche breakthrough into the regime as well as reveal uneven growth quality of niche growth in specific transitions situations. The analysis provides a backdrop to fathom issues of reverse salients in their context. The steps needed to anticipate reverse salients are to identify, diagnose and analyse major reverse salients that would critically impede transitions. During analysis, the goals of the solutions are determined and the timing of the intervention is specified. The goals and timing aid in the initiation of alternative solutions to correct the diagnosed reverse salients. Correcting reverse salients plays a vital role in initiating alternative solutions for short-term future planning, which is a keynote in the process. To implement the alternative solution, the following steps are needed to set guidelines for actions as well as prove the feasibility of the solutions. To ensure that the intended outcomes are achieved in the near future, and that the solutions do not engender any other undesirable outcomes, clear and strict guidelines in visual forms have to be developed to guide the intended actions. To prompt change plans from niches, the alternative solutions have to prove justified. Equally as important are the rationales behind the future design concepts. In this way, strategic design brings forward reverse salients to the forefront to prompt for present-day actions. Additionally, solutions visualised in visual and tangible forms increase effectiveness in successfully mitigating reverse salients.

The sequence likely develops an initial design process setting out in its rudimentary stage. This chronological narrative begins from analysing reverse salients and proceeds to operationalising strategic design solutions. This indicates that these five theoretical insights are sufficient to give suggestions to complete a design process to develop short-term future planning to mitigate reverse salients. These five insights, which have firm theoretical underpinnings, are now ready to be developed into a design approach for short-term future planning. Yet before further formulating them into a structured design process, empirical observation is necessary to sharpen the theoretical insights. Now this initial design approach comprised of five theoretical insights will go through case studies for confirmation of the proposition. If this initial design approach is supported with empirical evidence, these five insights will be further developed, formulated and organised into a genuine design process to guide design practice for sustainability transitions.

2.4. Chapter summary

This chapter presents an overview of the literature review of two fields of study – transitions studies and strategic design. The first section reviews transitions literature (Section 2.1). The review investigates the structural problems in sustainability transitions. The first section (Section 2.1.1) reviewing the fundamental concepts of transitions theories provides the basis to understand and explain the formation and stabilisation of a regime as well as the systems transitions for a niche breakthrough. The second section (Section 2.1.2) interprets and arranges three characteristics of problems in sustainability transitions. The three problem characteristics are persistent, unforeseen and critical problems. Having interpreted the persistent, unforeseen and critical nature of problems in systems sheds light on the concept of reverse salients. The third section (Section 2.1.3) synthesises the understanding to analyse three key transitions insights into anticipating problems in transitions, which provides implications regarding sustainability transitions for design practice. The three transitions insights are: transitions are involved in systems of interdependencies, reverse salients develop in the short-term future and reverse salients are corrigible.

After investigating problems inherent in reverse salients, the question of how to make the anticipatory measures concrete and operational to mitigate the reverse salients arising in transitions dynamics must be addressed. The second review (Section 2.2) of strategic design from design management literature investigates how to create short-term future planning. The first section (Section 2.2.1) begins from exploring the relationship between strategic design and corporate strategy, and is of major significance to strategic design. This significance is the importance of the operational elements of strategic design that produce intended results to fulfil shorter-term targets towards achieving longer-term goals. In this line inquiry, the second section (Section 2.2.2) scrutinises different strategic design activities to seek the operational elements of strategic design to analyse key strategic design insights. The third section (Section 2.2.3) draws two key insights into developing operational strategic design solutions for achieving the intended outcomes in the short term, which aims at realising long-term visions. The two insights are: strategic designs are instructive and strategic designs are working solutions.

In the last section (Section 2.3), the theoretical insights are developed into design implications to suggest their unique roles in addressing reverse salients. Transitions insights provide three suggestive implications to anticipate reverse salients – analysing transitions from a multilevel perspective, identifying reverse salients and correcting reverse salients with alternative solutions. Strategic design insights yield two design implications: setting guidelines for actions and demonstrating the feasibility of the solutions. Each role has clearly drawn its own scope and activities that are sufficient for each, and altogether the five roles are also adequate for developing short-term future planning. When putting the five theoretical insights together, connections amongst the insights are identified and an initial design process tends to be set out in sequence for guiding design practice. The five theoretical insights form an initial design process that is now ready to go through case studies aiming at capturing richer theoretical insights to enrich and refine the initial design process. Before proceeding to the case studies, the next section explains the research method for a logical and methodological process for case study research, which completes an empirically valid proposition.

3. Research method

This chapter explains the research method adopted for achieving the research aim. The aim of this research is to enhance design for sustainability targeting short-term future challenges with a view to realising sustainable visions. At this stage, two sets of insights drawing from transitions and strategic design literature are brought together, forming an initial design approach (Chapter 2). This proposition is ready to be investigated further for confirmation and theory building. To fulfil the research aim of enhancing design for sustainability, the proposition is to be investigated with real cases in the societal context to ensure practical relevance. For this reason, the case study method is adopted as a research strategy in this research.

When using the case study method, this research references several works in the field of case study research and in particular the work of Robert Yin (1984; 2009 [1984]; 2014 [1984]). Yin's work has made a prominent and ongoing contribution to case study research in social sciences over the years since its introduction in 1984. The work has been widely recognised and adopted by numerous researchers, including in the field of research on design for sustainability. One of the reasons for this is that the work provides practical insights into how to do case study research, which is particularly beneficial to novice researchers. Not only does it provide guidance for directing the design of case studies and practising case study methods, it also gives definitions and presents the logic behind processes, thereby guiding rigour to ensure research quality. Certainly, the current research also draws on work by other scholars who have made a strong contribution to specific areas in case study; for example, the work of Kathleen Eisenhardt (1989) on theory-building in case studies, Gjoko Muratovski's (2016) focus on design research, and the work of Thomas Cook and Donald Campbell (1979) on guiding research validity and reliability.

This chapter comprises two main sections. The first section explains and provides justifications for the use of case study as a research methodology and the design of a two-case study to investigate the proposed design approach (Section 3.1). The second section describes the case study process of developing the proposition. It explains the case-study procedure covering the major case study stages and case study methods alongside procedural protocols used to guide research quality (Section 3.2). The last section summarises this chapter (Section 3.3).

3.1 Research strategy

3.1.1 Case study research method

In this section, the justifications for adopting case study as a research method are explained. The research topic is the facilitation of sustainability transitions in their socio-technical systems. To facilitate transitions, this research seeks to understand the specific transitions situation of the phenomenon of reverse salients developing in the short-term future that often impede transitions towards realising sustainable futures. Achieving this understanding requires actual data and rich descriptions of the situation in order to explore and explain the phenomenon in a real context. For this reason, case study is appropriate for research that is exploratory and explanatory in nature (Yin, 1984; Gray, 2004). In addition, case study contributes to theory building through developing theory from its close linkage with empirical evidence (Eisenhardt, 1989). Case study research that is typically based on multiple data sources would yield rich empirical evidence. At present, a proposition is ready, and thus a case study is carried out to further develop the proposition. The following provides more specific reasons for why the case study method is appropriate for this research project.

The unit of analysis

This research project targets contemporary transitions phenomena situated in their socio-technical systems, which defines the unit of analysis of this research. Yet the complex contextual conditions of socio-technical systems demand investigating not only the phenomenon itself but also its context. Particularly, the contextual conditions of the transitions cases underlying slow and difficult transitions phenomena need to be investigated in a natural setting through case study. In this view, a case study – as a qualitative research method for empirical inquiry – is able to investigate a contemporary phenomenon while also covering the contextual conditions and thereby provide rich qualitative data. This would yield a rich and insightful account of the phenomenon for design exploration (Yin, 2009 [1984]).

Developing the proposition

The proposition developed earlier has solid theoretical underpinnings from two fields of study – transitions theories from the transitions literature in addition to social studies of technology and strategic design from the design management literature. The proposition is ready to be investigated through empirical research for validity and improvement. That said, to affirm the outcome of this proposition, a logical and methodological theory-developing process is vital. The case study method has its strengths in building, refining and extending theory through capturing theoretical insights from empirical evidence (Eisenhardt, 1989; Eisenhardt and Graebner, 2007). This is how a case study contributes to building theory and eventually developing theories that are novel, testable and empirically valid (Eisenhardt, 1989). Using case study in this research would develop the initial proposition into an empirically valid design approach to explain and guide design practice for sustainability.

New design approach

Case study has been a common qualitative research framework used in design to explore new concepts or investigate the validity of proposed theoretical concepts (Muratovski, 2016). The fact that case study builds theories through its close linkage with empirical evidences instead of prior established theories makes it particularly suitable for exploring new research areas (Eisenhardt, 1989). This design research that aims to develop strategic design for short-term future planning targeting reverse salients is identified as an unaddressed research area in the field of design for sustainability (this has been discussed in the Introduction, Chapter 1). To enhance design for sustainability in this particular focus area requires taking new steps forward from an alternative perspective for a new design approach to sustainability transitions. Having defined the focus, case study as a research method that approaches theory-building from empirical observation would guide this research to develop a new design approach and, as a result, generate new knowledge that contributes to the design research community.

3.1.2 Research validity and reliability

Establishing research quality is essential for increasing the credibility of research findings to eventually produce new knowledge. To increase the credibility of research, validity and reliability comprise the quintessential qualities. In simple terms, validity refers to the accuracy of measurement, and reliability refers to the repeatability of the measurement. However, in qualitative research, the concept of measuring a phenomenon in its context (with accurate and repeated results) is not simple.

Research validity involves two types of validity – internal and external. Internal validity is defined as the approximate validity with which a causal relationship is inferred between two theoretical constructs. External validity is defined as the approximate validity of the presumed causal relationship that can be applied to and across different types of settings and conditions (Cook and Campbell, 1979). Using “approximate” when referring to validity implies that the truth or falsity of propositions can never be exactly known, which means that the findings remain tentative, representing the best available at the time (Cook and Campbell, 1979). In view of qualitative research with regard to validity and reliability, employing a logical and systematic case study process is vital for the quality and credibility of research results.

Insofar as causal relationships between constructs are concerned, measuring internal validity can be reflected by the significant associations between the cause and outcome in a case – that is to say, how a cause leads to its intended outcome (Gray, 2004; Yin, 2014 [1984]). The causal outcome link examined in this research project is how the proposition integrating transitions and strategic design insights results in developing strategic design for short-term future planning. To build the internal validity of this research, the developed proposition has a strong theoretical underpinning. In this way, the firm and explicit proposition guides the research focus onto relevant causes leading to the intended outcome without being overwhelmed by a huge amount of empirical data. In addition, the firm theoretical grounded proposition, though a priori, can be explicitly assessed with the outcome from empirical observation (Eisenhardt, 1989). This enhances the identification of relevant and emergent causes and links in the cases. Within-case analysis is also structured to ensure a thorough analytic process to richly explain individual cases and analyse and review backward and forward iteratively between theoretical insights and empirical evidences. This aids in revealing further subtle relationships within the case in order to strengthen the causal relationships whereby the theoretical proposition leads to the empirical outcome (Eisenhardt, 1989).

To measure external validity, the presumed causal relationship that can be applied to different types of settings and conditions is reflected in the recursive pattern of the relationships amongst theoretical insights and empirical evidences across cases (Eisenhardt, 2007; Yin, 2014 [1984]). This builds the external validity of the theoretical proposition that can be applied from one case study to others. To identify recursive patterns of the relationships, first, analysis is conducted within the cases to compare theoretical insights and empirical evidences in each case. Afterwards, cases are put together to discuss whether cases applying the theoretical proposition would produce the intended outcome of developing short-term future planning and how. To further increase external validity, the cases selected should have comparable key characteristics, both between the cases and with other cases in similar transitions settings (Gray, 2004). To support comparability, a set of case selection criteria is given to enable the careful selection of appropriate cases for empirical research.

The research quality of reliability refers to the repeatability of similar case study results of this research. Reliability can be assessed based on the research methods applied and the meticulousness taken in the entire research procedure in a case study (Yin, 2014). To enhance greater reliability, a multiple-case study design should primarily be adopted with the aim of drawing similar case results across cases, as the cases cannot be identical. In addition, a systematic case study procedure should be followed from data collection and documentation through to analysis. Throughout the case study procedure, clear procedural guides should be set up for different stages. Very importantly, multiple research methods of case study should be applied to obtain data from multiple sources, which enhances the full explanation of the case and also the counter-checking of the data.

The last point regarding research quality concerns the role of the researcher in this research – that is, my role as the researcher. Throughout the research project, I played the researcher role to conduct qualitative research. Yet I am also a researcher with knowledge and expertise in design from my professional design career. As a designer, I am able to produce and enhance the deliverables of the strategic design solutions in the two case studies. My design skills contribute to the design results by generating a high quality of visualisation. However, that expert design knowledge does not prejudice the entire case study procedure from data collection and documentation through to analysis for establishing a chain of evidence. In other words, my design knowledge does not interfere with the research, unlike in action research where design fosters faster changes from a high engagement position (Levin, 1944) or in constructive design research where construction of design is vital in creating knowledge (Koskinen et al., 2011). Instead, in this research, the researcher's knowledge and skills in design practice are limited to expressing the design solutions in the most effective ways relevant to the cases at hand. It is an awareness that the research quality of reliability must be strictly maintained.

In closing, by explaining the concepts of building validity and reliability to increase the credibility of research, this case study research seeks to maintain the research quality of validity and reliability.

3.1.3 Two-case study

Case study research involves single-case and multiple-case studies. In this research, a multiple-case study is planned for identifying patterns of relationships between theoretical insights and empirical evidences across cases. This would enable the application of the theoretical proposition to other cases beyond the current research for wider relevance. In this research, a two-case design is specified with the aim of having two different examples to cover a larger range of transitions cases (Flyvbjerg, 2006). In a two-case design, if both cases – in varied contexts but with key common transitions characteristics – support the theoretical proposition, the proposition may be applied to other different cases.

Moreover, in a case study, cases are chosen not to be representative of a specific population, as statistical sampling would require. Rather, different cases are chosen in order to yield richer theoretical insights from their distinctive empirical evidence, which aims at refining and developing the original proposition (Eisenhardt and Graebner, 2007). This justifies a small case study as long as a meticulous case selection process is ensured. For this reason, a set of selection criteria for cases appropriate for this research is set up; these criteria will be discussed in the coming section.

Last, regardless of the high complexity of the unit of analysis in this research – contemporary transitions phenomena situated in their broad socio-technical systems – the proposition is a relatively firm and explicit proposition developed from a literature review. This firm and explicit quality of the proposition enhances case analysis for identifying the predicted insights (theoretical insights) as well as new insights (empirical evidences) leading to the intended outcome (developing short-term future planning). This is another reason why a two-case study is settled on. However, the findings from this two-case study are not to be exaggerated although a structured methodological research process is followed. Rather, this research that begins from a small case study might put forward a new research area addressing unanswered research areas of design for sustainability. This might set a new design direction involving the application of the proposition in different transitions contexts for short-term future challenges in transitions.

In summary, this section has provided a justification for selecting case study as a research method for this research project. Case study suits the unit of analysis of this research, develops the proposition and delves into the unaddressed research area in the field of design for sustainability. In addition, several approaches to building research validity and reliability are explained. Finally, a two-case study design is planned in this research in order to capture richer theoretical insights from distinctive empirical evidence in two different cases.

3.2 Case study procedure and case study methods

3.2.1 The two-case study procedure

Having justified the adoption of case study as the research method, the approach adopted to manage the research in a systematic and logical manner emerges as a technically important issue. Planning an appropriate case study procedure could increase the quality of validity and reliability of the research findings (Yin, 2014 [1984]). This section describes the case study procedure, suggesting procedural protocols to guide maintaining the research quality of validity and reliability. A diagram is presented below to illustrate the whole two-case study procedure. (Figure 4. The two-case study procedure, adapted from Yin, 2014 [1984]: 60).

The diagram shows the sequence of the two-case study procedure in this research. The procedure covers three major stages: (1) define and design case study, (2) collect, document and analyse data and, (3) conclude and improve. The first stage – define and design – refers to the development of a proposition and case selection. In this research, an initial design approach has already been proposed and is ready to be investigated through this case study. Case selection concerns choosing the appropriate cases for developing theoretical insights through empirical investigation. The second stage – collect, document and analyse data – represents empirical research for collecting, documenting and analysing data on the two cases (Case study 1 and Case study 2) in the field. This stage also details within-case analysis of individual cases. The last stage – conclude and improve – works on a two-case analysis and draws the analysis conclusion by comparing the two cases in terms of theory development. Besides the sequential order of the procedure, a dotted-line loop linking the boxes of the proposition and within-case analysis represents the constant iterations between the proposition and case data. This symbolises how the proposition tends to be improved, developed and iterated from empirical evidence.

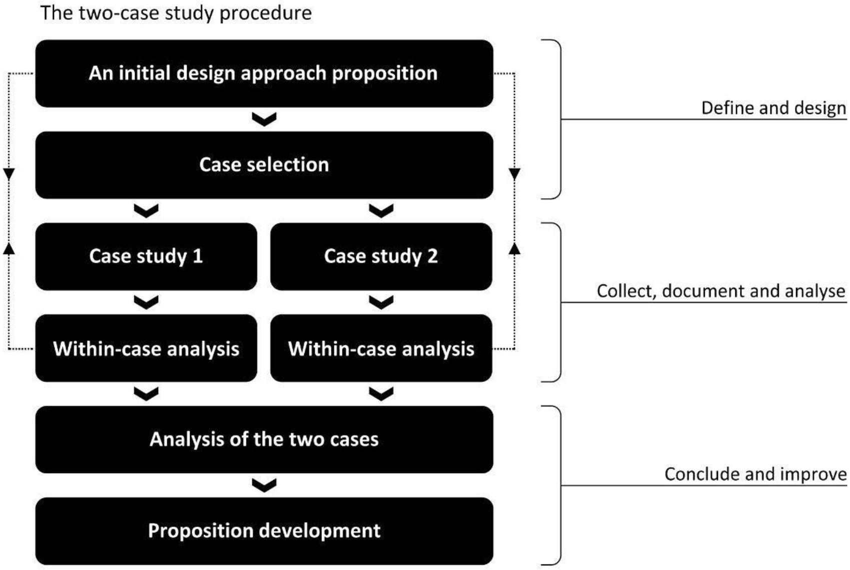

Figure 4. The two-case study procedure of this research project (adapted from Yin, 2014 [1984], P60).

The proposition of an initial design approach

In this research, a proposition for an initial design approach to strategic design for sustainability transitions has already been developed and is ready to be investigated through case study research. The proposition has a solid theoretical underpinning from theoretical insights drawn from a literature review. The insights are drawn from two fields of study – transitions insights from transitions literature and strategic design insights from design management literature. This initial proposition assumes that adopting the integrated knowledge would enhance design for sustainability at the systems level. From this case study research, it is expected that empirical observation will yield more theoretical insights. Capturing richer theoretical insights from empirical observation improves and develops the original proposition – which aims for an empirically valid design approach for organising it into an ultimate design process to guide design practice.

Case selection and case selection criteria

At this stage, a deliberate case selection process is arranged. Setting up criteria for case selection is necessary to identify appropriate cases for specific theoretical development. Primarily, candidate cases should conform to the unit of analysis. In this research, the unit of analysis is defined as the contemporary transitions phenomena situating in their socio-technical systems. This definition has already described several key aspects of potential cases appropriate for this case study research. In addition, as stated earlier, the goal of selecting cases in this research is to look for cases that are applicable for the theoretical proposition and thereby extend the proposition. Based on this goal, it is necessary to seek cases that have key common characteristics for comparison purposes. Based on these two statements, several key characteristics shared by the cases can be noted. The selected case should be (1) at the socio-technical systems level. This means that the case should involve a technological shift that co-evolves with societal changes towards sustainable futures. (2) A contemporary transitions situation. The case should be a situation – a process transitioning in its long-process ongoing transitions pathways towards the sustainability visions. Due to the long-process ongoing nature of transitions, (3) the case should include sustainability goals at different time frames, typically short-term, medium-term and long-term. The timescale frames design intervention to orient transitions pathways according to short-term and mid-term goals towards the longer-term visions. It is also due to the reason that the near future per se does not adopt a definite timeframe but relies instead on the identified problems inherent in the short-term future. This enhances the capabilities of design to investigate opportunities to engage in short-term future planning. Moreover, cases in case study research should not be seen as merely representatives of some population like sampling, as mentioned earlier (Eisenhardt, 1989; Eisenhdart and Graebner, 2007). Rather, (4) the case for theory development should have the potential to enable capturing distinct and richer theoretical insights from empirical evidence. In this way, empirical observation helps to refine and develop the original theoretical proposition.

It is necessary to state the scope of the application of the proposition in order to put the findings together for analysis (Lucas, 2003). Under the selection criteria, the first three criteria tend to bind the applicability of the theoretical proposition to the types of transitions cases that are appropriate for investigating the proposition. The last criterion in turn tends to open up potential to allow new insights to emerge from empirical observation. This set of case selection criteria is designed with expectation that the cases will be applicable for the theoretical proposition as well as to refine the proposition.

The case selection criteria are summarised below. The appropriate cases should:

1. be at the systems level
2. involve a contemporary transitions situation
3. include sustainability goals at different timeframes
4. have the potential to investigate more distinct and richer theoretical insights

The first transitions case is renewable energy transitions applying to Dipoli's renovation (Case study 1) and the second case is sustainable aquaculture transitions applying to Finnish sustainable salmon trout aquaculture in the Baltic Sea (Case study 2). Both cases fulfil the case selection criteria. (1) First, they are both transitions cases at the socio-technical systems level. Case study 1 is situated in the context of renewable energy systems to facilitate solar technology. The transition involves a technological shift from fossil fuels to renewable energy generated with solar technology. Case study 2 involves Finnish sustainable salmon trout aquaculture in the Baltic Sea, situating in the context of broader sustainable aquaculture systems. The transition involves sustainable aquaculture technologies. (2) Second, they are contemporary transitions situations. Case study 1 concerns installing solar photovoltaic (PV) panels on built heritage – Dipoli is part of the ongoing renovation plan to modernise heritage buildings to achieve an energy self-sufficient university campus for Aalto University, Helsinki, Finland. Case study 2 is part of the Finnish National Aquaculture Programme to facilitate salmon trout aquaculture to increase fish production by 2020. (3) Third, case study 1 involves the short-term goal of renovating the heritage building by 2015 and the longer-term goal of realising the vision of an energy self-sufficient campus by 2030. Case study 2 has the short-term national goal of increasing farmed fish production by 2020 and the mid-term EU vision of the Blue Growth strategy towards achieving the longer-term global UN Sustainable Development Goals (SDGs) by 2030. (4) Last, case study 1 applying to Dipoli's renovation involves huge debates regarding heritage values and aesthetic quality, which critically may lead renewable energy transitions to undesirable outcomes in short term. The case would be appropriate for investigating the design approach proposition in order to yield rich theoretical insights to improve the initial design approach proposition. Case study 2 has a different context than the first case study, but it would have similar adverse consequences without the aid of an intervention. In this case, it is also evident that siting fish farms in the Baltic Sea would spark huge debates regarding eutrophication in the sea or the total prohibition of fish farming activities in the Baltic Sea – in this case, it would lead the Finnish sustainable aquaculture transitions to unwanted results. Against a variety of more complex backdrops of the transitions situation, the case would be suitable for investigating the proposition to yield richer empirical insights to develop the initial proposition. As it fits the case selection criteria, this case is appropriate for the present case study research.

Data collection, documentation and analysis

This stage describes the methods for data collection and analysis, as well as documentation and presentations conducted in the research.

Logic should be maintained between the empirical data and theoretical proposition when collecting and analysing a huge volume of qualitative data in the field (Yin, 2014). An investigation of a contemporary phenomenon within its real-life context rarely presents an evident demarcation between phenomenon and context. This may pose the risk of collecting and analysing insufficient and irrelevant data. To increase the research quality of validity and reliability, maintaining a logic is particular important to avoid overwhelming and irrelevant empirical data and emergent links. The logic also bounds the scope of data collection and analysis during the research process to within the research focus in order to ensure coherent data collection and analysis. This demonstrates the collection of a chain of relevant evidence that complies with the theoretical proposition (Yin, 1984; 2014; Gray, 2004). Moreover, data collection and analysis are often conducted simultaneously, as in any qualitative study (Baxter and Jack, 2008).

To obtain empirical data, typical case study methods are suggested, including interviews, observation, literature search, document analysis, on-site prototyping and technical analysis. Collecting information from multiple sources and through different ways facilitates the validation of data. Multiple sources of evidence are essential to corroborate the data and thereby avoid biased data (Yin, 2014 [1984]). In managing a large amount of qualitative data, several techniques, such as managing a case study database, are used to organise the data to aid analysis. In the process, different data collection methods are often used in conjunction with each other and the data collected from various methods are always integrated and analysed together (Muratovski, 2016). The following is a table listing different case study methods adopted in the two cases. The table also presents details of dates, durations and other necessary information regarding the research activities. (Table 5. Case study methods used in the two case studies).

Table 5. Case study methods used in the two case studies. Additionally, details of dates, durations and other necessary information regarding the research activities are also noted.

Case study methods	**Case study 1: Renewable energy transitions case applied to Dipoli's renovation**	**Case study 2: Sustainable aquaculture transitions case applied to Finnish salmon trout aquaculture transitions**
Field observation	▪ The everyday activities of entering and exiting Dipoli and the rooftop where solar PV is intended to be installed. The surroundings are also observed. ▪ Field visits made on 13, 17 and 26 November 2014, each time for a half-day session. ▪ Documentation in photos and field notes.	▪ Observation of fish farming activity on a fish farm in the Archipelago Sea of the Baltic Sea in the recommended "good water area". ▪ A one-day field visit made on 26 May 2016. ▪ Documentation in photos, audio recording and field notes.
On-site prototyping	▪ Prototyping different options for siting solar PV modules on the rooftop of the heritage building to observe the interaction between stakeholders and the solar PV installation. ▪ Two real solar PV modules provided by a solar PV company, Naps, prototyped on Dipoli rooftop on 2 December 2014. The prototyping was carried out between 1-3 pm. ▪ Documentation in photos and field notes.	▪ None

Interviews with key stakeholders	▪ Architects, a heritage researcher and users of the heritage building are interviewed. ▪ Email interview with the Pietilä architecture legacy holder on 16 Nov 2014; email correspondence with a professor of architecture on 15 November 2014; interview with the heritage researcher on 20 November 2014, 2-4pm; and several email conversations during 20 – 21 November 2014. ▪ Fifteen short interviews with users of the heritage building on 2 December 2014, 1-3pm, at the entrance of Dipoli, and five in the cafeteria on the second floor inside Dipoli. Each interview took 10 minutes. ▪ Documentation in emails and minutes of meetings.	▪ The representative of each important entity is interviewed. ▪ Interview with the Senior Officer of the Ministry of Agriculture and Forestry on 30 November 2015 for 1.5 hours in order to understand the case background and on 24 May 2017 for 1 hour to review the research results. ▪ Interview with a researcher of the Natural Resources Institute Finland (Luke) on 15 December 2015 for 2 hours and on 25 May 2016 for 2 hours. A last interview on 21 August 2017 for 1 hour to review the research results. In addition, several email conversations during 4 December 2015 – 15 December 2016. ▪ Interview with the Director of Environmental Permits and the Environment Counsellor of the Regional State Administrative Agency for Southern Finland (AVI) on 29 November 2016 for 2 hours and email interviews during 15 – 19 December 2016 for more discussions. A last interview on 22 May 2017 for 1 hour to review the research results. ▪ Interview with a fish farm manager on 26 May 2016, the same day as the field observation, for 4 hours. ▪ Interview with the Managing Director of the Finnish Fish Farmers' Association on 5 October 2016 for 2 hours. ▪ Interview with the Head of Programme of the World Wildlife Fund Finland (WWF Finland) on 17 June 2016 for 2 hours and a second one on 7 June 2017 to review the research results. ▪ All interview documentation in audio recordings, field notes and minutes of meetings.
Literature search	▪ Architectural literature review and archival research with focuses on the architectural values of Dipoli. ▪ Major literature was sourced from the library and archives of the Museum of Finnish Architecture, Helsinki, Finland. Several reviews accessed from online sources. ▪ Heritage report on Dipoli 2015 was received from the heritage researcher.	▪ Historical review of Finnish aquaculture development with a focus on events that have caused the contemporary societal disapproval of increasing aquaculture in the Baltic Sea. ▪ Major literature sourced from Luke; several reviews from WWF, the Finnish Fish Farmers' Association, the Baltic Marine Environment Protecting Committee (HELCOM). A few reviews accessed from online sources.
Document analysis	▪ Documents include production and consumption data on solar and other renewable energy in the Finnish energy market; ongoing measures and schemes in Finland. ▪ Most documents are received from Professor Sampsa Hyysalo who is involved in setting up the project. Several documents accessed from online sources.	▪ Documents on existing measures and aquaculture policies. ▪ Major documents obtained from Luke, including new fishmeal information. In addition, some calculations relevant to farmed fish production were counter-checked with Luke.
Technical analysis	▪ Technical analysis of the internal Report of Energy Self-Sufficient	▪ None

	Otaniemi, some public use files and simulated energy figures from the European Commission Institute for Energy and Transport for the solar irradiance map of the Dipoli area. ▪ Energy consumption reports 2009-2014 obtained directly from Aalto University Properties on 8 – 9 December 2014. ▪ Counter-check of solar yield calculation of Dipoli with Naps during 4 – 8 December 2014. ▪ Rooftop area plan of Dipoli received from ALA Architects on 10 December 2014, which was commissioned as part of the Renovation Plan of Dipoli.	

The two case studies in this research are: the first case is renewable energy transitions (Case study 1) and the second case is sustainable aquaculture transitions (Case study 2). The following describes several key case study methods applied in the case study.

As this case study takes place in real-world settings, conducting field observations is necessary to understand the actual environment of a particular phenomenon (Yin, 2004). The method of observing people and the environment in their actual setting yields insights that make a distinctive contribution to understanding the contextual influences on a specific phenomenon, based on data that is unavailable from other case study methods (Yin, 2004; Morgan et al., 2017). In case study 1, observation was performed at the site of the heritage building on which the rooftop solar PV panels were intended to be installed. Users of the heritage building were observed at the site, with a focus on their everyday activities of entering and exiting the building. In addition to observing users at the doorway of the building, the environment at various spots surrounding the building as well as its rooftop where solar PV modules were to be installed were observed. The heritage rooftop was visible to passers-by from the different spots covered, both near and afar. In case study 2, observation was conducted at the Archipelago Sea of the Baltic Sea, the site recommended for fish farms by the Finnish Ministry of Agriculture and Forestry. Access to the site was granted by the Natural Resources Institute Finland (Luke). The observational data informs the understanding of the environmental conditions involved in locating fish farms offshore, in which remoteness and weather challenges are of crucial concern. At the site, fish farmers were observed with a focus on their activities of fish farming and fish feeding. The observational data is documented in field notes and photographs.

Other than field observation, on-site prototyping was used in case study 1. Real solar PV panels were set up on the heritage rooftop during the design process as the issue of aesthetic appeal requires deeper evaluation to refine the views articulated by stakeholders. The intention was to observe how users of the heritage building responded to different solar PV siting options and, based on their responses, encourage them to articulate their views. This method has offered rich evidence and yielded in-depth insights to support the final strategic design intervention.

The interview method is also used because some implicit understandings underpinning one's behaviour usually cannot be directly observed (Arksey and Knight, 1999). Through conversations, the interviewees are asked to express their interpretations and opinions or further guided to articulate their in-depth perceptions about the situations under study (Gray, 2004; Yin, 2014 [1984]). Before interviewing, initial background research on both cases relevant to the studied phenomena is conducted with the aim of finding the right people for interviews (Muratovski, 2016). This is especially important as transitions always implicate a diverse group of stakeholders. Typically, the interviews are semi-structured in order to probe in-depth and expandable information from informants.

In case study 1, interviews were conducted with key stakeholders, including users of the heritage building, architecture experts and a heritage researcher with the knowledge of Dipoli. Targeting users of the heritage building, a short interviewing technique was deliberately used while users were entering or exiting the building (Gray, 2004). These interviews were brief, only a few minutes, which required posing focused questions. Expert interviews with architects and a heritage researcher with the knowledge of Dipoli were asked about their opinions based on their perceptions as well as expert knowledge on installing solar PV modules on heritage buildings. A prolonged interviewing technique was applied to probe the expert informants on particular issues (Muratovski, 2016) and the interviews usually took place over two hours (Yin, 2014). In some cases, key informants could be identified during the interviews at the time when they expressed crucial information or critical views. The data from such informants often becomes pivotal to a case study, yielding key theoretical insights that should be accurately captured (Yin, 2014 [1984]; Muratovski, 2016). One original source of information was an architect who is a key legacy holder of Dipoli; she provided immediate views on modifying her ancestral architectural design. Another interview was carried out with an architecture professor who was developing the university campus. His comments were recognised as critical information, yielding crucial insights on factors that might to a great degree hamper solar PV installation in Dipoli. A conservation architect was deliberately chosen to be interviewed for his professional view on preserving Dipoli. He was commissioned to make a heritage preservation study of Dipoli in which his analysis about Dipoli also offered insightful information on understanding Dipoli's renovation.

In case study 2 (the aquaculture case study), the expert interview method was mainly used to interview the representatives of each important entity. This was done because the various key roles in this transitions situation might have restrained each other and it was thus necessary to examine their thoughts. Questions focused on their views on adopting the new concept of recirculating nutrients and siting fish farms offshore in the Baltic Sea. Applying a prolonged interviewing technique aimed at probing the informants for in-depth and expandable information. The Senior Officer of the Ministry of Agriculture and Forestry who led the National Aquaculture Programme was interviewed in order to determine the Finnish sustainable aquaculture vision and the reasons behind launching the recirculating nutrients concept and selecting offshore fish farm sites in the Archipelago Sea of the Baltic Sea. Researchers from the Natural Resources Institute Finland (Luke) were interviewed to gain an understanding from their research about how the new recirculating nutrients concept and newly identified offshore fish farm sites in the Baltic Sea were justified to support sustainable aquaculture in the sea. The Director of Environmental Permits and the Environmental Counsellor of the Regional State Administrative Agency for Southern Finland (AVI) were interviewed to shed light on the rationales behind the stringent legislation on fish farm licensing in the Baltic Sea. Apart from the planning perspective, fish farmers and the Managing Director of the Finnish Fish Farmers' Association were interviewed to grasp their views on ongoing sustainable aquaculture schemes from a daily operation perspective. Last, the Head of Programme of the World Wildlife Fund Finland (WWF Finland) was interviewed to gain an environmental perspective on the studied phenomenon. In time, he was identified as a key informant who offered crucial information and insights into this specific aquaculture transitions case, making a great contribution to the success of this aquaculture case study.

For documentation purposes, all interviews were audio recorded and afterwards transcribed and analysed in detail using the recordings. Moreover, direct quotes were extracted to report and highlight key insights that are important to the cases. Although the interviews have shed light on the unique insights of interviewees into specific transitions situations, their personal views might be biased due to their personal interests, unreliable recall or inaccurate articulation. Therefore, the views of stakeholders were compared and contrasted to identify both common and conflicting perceptions that might yield insights into the cases. At some crucial points, the interpretations of the data were shared with several key stakeholders for the sake of clarifying the interpretations with them and gaining their new and additional views on the issues (Baxter and Jack, 2008).

A rich explanation of specific situations may also require delving into their historical dimension to offer background knowledge on the cases; this enriches the understanding of transitions development in order to explain the contemporary transitions phenomenon. In this view, literature search is to be used for historical review purposes. The analysis of recent documents should also be used to review updates concerning contemporary transitions phenomena. In case study 1, both historical review and analysis of recent documents are used. An architectural literature review and archival research were conducted. In the search, publications by both the architects of Dipoli and other architectural authors were reviewed. The publications included books, essays and articles in architectural magazines. In addition, collections of historical documents, photos and records of Dipoli archived in the local archives of the Museum of Finnish Architecture were sourced and studied. In addition to the historical review, document analysis was also conducted to analyse the sources of Finnish renewable energy in the broader context. The analysis included solar energy and other renewable forms of energy in the current Finnish energy market, and their measures and schemes. Furthermore, technical data must be collected and studied for technical analysis in order to justify the technical and economic viability of any design proposal. A recent energy consumption report on the built heritage was obtained from the internal Report of Energy Self-Sufficient Otaniemi in addition to other public use files. Moreover, energy figures were simulated and sourced from the European Commission Institute for Energy and Transport for the solar irradiance map of the area where the built heritage was located. These technical analyses calculated different yield options of solar energy to clarify the technical and economic viability of installing solar energy in built heritage.

In case study 2, a historical review of Finnish aquaculture was conducted to provide background data to explain the scepticism of the public towards increasing salmon trout farms in the Baltic Sea; this scepticism has demotivated the Finnish aquaculture industry. In addition to the historical review, document analysis of existing aquaculture measures and policies was used to provide updates on the transitions situation.

In the process of data collection, the raw data is documented in the format of field notes, document files, emails, minutes of meetings, photographs and audio recordings of all interviews. All files are identified with recording time, date and other necessary source details. They are compiled in an organised database and kept in computer folders that can be tracked and conveniently accessed for analysis at any time. In the process, data are also properly presented in a clear format, for example, as organised text, images, and graphical and tabular presentation of data for objective data interpretation, which aims at demonstrating unbiased inquiry. In this study, analytic methods of case description, case report, narrative and building explanation are used to draw sets of causal links between the thoughts of key stakeholders and issues in transitions (Yin, 2014 [1984]).

In the logic between the theoretical proposition and empirical data, the theoretical proposition has already scoped the data collection and analysis plan, and as a result has also drawn a case boundary to inform the completeness of the case study (Yin, 2014 [1984]; Gray, 2004). When there are no further iterations between the theoretical proposition and the empirical data, this means that the data collected should be sufficient and relevant to support the proposition, indicating that each case has been sufficiently and relevantly investigated in depth and that the case study is complete.

Within-case analysis

This step of within-case analysis refers to analysing the individual case in detail and starting a discussion about the case. First, detailing within-case analysis is a key step in which theoretical insights are often generated. They may emerge through analysing and reviewing theoretical insights and empirical data backward and forward iteratively (Eisenhardt, 1989). Second, the in-depth analysis also seeks significant associations between the cause and outcome in the case and through identifying the causal relationship builds the internal validity of research. Third, in addition, becoming familiar with the individual case through in-depth analysis enhances the review when analysing the two cases in the next step (Eisenhardt, 1989).

Analysis of the two cases

Building external validity aims at confirming the theoretical proposition and is applicable to explaining both cases in this research. This applicability is in regard to their design processes to develop strategic design for short-term future planning. This stage organises an analysis of the two cases. In the analysis, the two cases are compared to analyse the application of the proposition in producing the intended case results of developing short-term future planning. The analysis seeks to reflect the pattern of cause-effect relationships in the two individual cases, which identifies important factors causing the recursive functions of the theoretical proposition in the two cases. The identified patterns enrich and develop the initial proposition and widen the application of the proposition to other similar cases as well.

The mechanism behind the analysis of the two cases lies in the logic of two-case analysis. At the outset of this case study research, case selection criteria are set up, as described earlier, to identify appropriate cases for drawing causal-effect relationships within individual cases. The identification of a presumed pattern of relationships in the two cases strengthens the likelihood of applying the theoretical proposition to other cases in similar settings. It is expected that the analysis of the case data will yield not only the predicted insights, but also new insights that contribute to the intended outcomes. The new insights – if they again follow a pattern of relationships (that is, the new insights lead to the outcome of developing short-term future planning) – would enrich the theoretical insights to improve the original proposition (Eisenhardt, 1989).

To aid analysis, the analytic technique of pattern making is used in which matching is based on the fit of the case data to the proposition. In this way, a matching or mismatching result will either confirm or disconfirm the original proposition (Yin, 2014). Another analytic technique that is useful in a case study is to build explanations by tracing the design processes of cases (Yin, 2014). These explanations built through tracing processes investigate how the insights are adopted throughout the design process in the cases. This is essential to discover subtle similarities and deeper causal links underlying the causal relationship, thereby yielding richer theoretical insights.

Proposition improvement and development

A well-managed case study would yield good theory that is new, testable and empirically valid at the end of the case study but not at the start (Eisenhardt, 1989). At this final stage of the case study procedure, when most of the theoretical insights have been captured from empirical evidence without further new insights to be added, this indicates that the research has almost come to the end. The original design approach proposition is then refined, improved and furthermore developed into an empirically grounded final design approach to enhance design for sustainability at the systems level, which fulfils the overall research aim.

To summarise this section, it has described a two-case study procedure, which covers three stages from (1) defining and designing a case study, (2) collecting, documenting and analysing data, and (3) concluding the case analysis results and improving the original design approach proposition. The procedural protocols and major case methods have also been explained in each stage.

3.3 Chapter Summary

This chapter has explained the adoption of the case study method as a research strategy to achieve the research aim of enhancing design for sustainability at a systems level for short term. In this research, an initial design approach proposition that was developed is ready to be applied to case studies for investigation with the aim of improving the proposition. This develops an empirically valid theoretical design approach for design practice.

The first section provides justifications for why case study as a research method was selected for this research project. First, the case study method is qualitative research for explaining and exploring real-life phenomena in their contextual conditions. This suits the unit of analysis of this research – the contemporary transitions phenomenon of reverse salients developing in the near future situated in their socio-technical systems. Second, one strength of the case study is that it develops empirically valid theory. This research project requires practical insights into facilitating transitions in real-world settings. In this way, adopting the case study method enables the development of a theory that has a firm empirical grounding. Third, case study design builds theories through empirical investigation rather than prior established theories, which makes it suitable for exploring new research areas. This suits this research, which contributes to an unaddressed research area in the field of design for sustainability. For building the research quality of validity and reliability, several main criteria are defined to justify the making of causal relationships between theoretical insights and empirical evidences. The criteria require the presence of a theoretically sound proposition drawn from a literature review, supported with clearly described theoretical insights, a set of case-selective criteria for comparability of cases, a rich description and iterative analysis of individual cases for the internal logic of cause-effect relationships between the proposition and case study, an iterative analysis of cases for identifying patterns of cause-effect relationships in cases and the adoption of multiple research methods. Adopting a two-case study is also justified due to the deliberate use of two different case studies to yield distinct empirical evidence from their different contexts. Yet, given the justification, this research will not exaggerate the findings from a two-case study design. Rather, the research, based on a sound case-study procedure, shall put forward a new design direction to ensure greater similarity of results in different transitions contexts.

The second section describes the two-case study procedure to guide the investigation of the initially proposed design approach in a valid and reliable manner. The case study procedure covers three stages from (1) defining and designing the case study, (2) collecting, documenting and analysing data, and (3) concluding the case analysis results and improving the original theoretical proposition.

At present, the proposition – that is, adopting the proposed design approach integrating transitions and strategic design insights would enhance the development of strategic design solutions for short-term future planning to mitigate problems in transitions – is ready to be applied to real cases for theoretical investigation. This is done through the two-case study procedure that has been introduced above. After case studies, analysis of the two cases (Case study 1 and Case study 2) will be conducted to improve and develop the original proposition into a refined form.

4. Case studies

An initial design approach to strategic design for the short-term future has been proposed as a result of reviewing two streams of literature in Chapter 2. The proposed design approach is firmly grounded by two sets of insights – transitions theories from transitions literature and strategic design from design management literature. It is assumed that adopting this proposition that integrates the two sets of insights would result in enhancing design to develop strategic design solutions for short-term future planning to mitigate reverse salients in transitions. The application of this initial approach in case studies aims for improvement and thus the improvement of the proposition builds an empirically valid design approach for design practice. At present, the proposition is ready to be applied to real cases and work on empirical data to capture richer theoretical insights from empirical evidence. Five insights developing five respective design implications have formed an initial design proposition. The five design implications are – (1) analysing transitions from a multilevel perspective, (2) identifying reverse salients, (3) correcting reverse salients, (4) setting guidelines for actions, and (5) demonstrating the feasibility of the solutions. These five design implications will guide the design process of the two cases.

Very importantly, a within-case analysis is analysed in detail after each individual case study. This is important because richer insights are typically generated through analysing and reviewing theoretical insights and empirical data iteratively (Eisenhardt, 1989). In an argumentative manner, the analysis reviews and elaborates each case, and identifies and explains emergent insights and their intimate links through analysis and examination in written form. This in-depth analysis also identifies significant causal relationships between the proposition and case results. Strengthening the causal relationship would build the internal validity of the research to enable the replication of the case results of this research to other similar transitions cases. Finally, detailing within-case analysis is important to becoming familiar with individual cases through in-depth dissection, thereby enhancing cross-case analysis in the next step (Eisenhardt, 1989).

The two transitions situations cases explained here are deliberately chosen as the case studies. The first case concerns renewable energy transitions (Case study 1) (Chapter 4.1) and the second case involves sustainable aquaculture transitions (Case study 2) (Chapter 4.2). They are discussed below. Each discussion is structured as follows: first, the background of the case is introduced and it is explained why and how the case is selected to be appropriate to evaluate the proposition, the design process is explained in terms of how the design approach proposition is applied, the design results of applying the proposition to the cases are presented and, finally, a within-case analysis is detailed to investigate the proposition. A chapter summary is presented at the end of this chapter (Chapter 4.3).

4.1 Case study 1: Designing for renewable energy transitions

The design exploration was done in autumn 2014[6], which was an opportune time to intervene to facilitate solar PV at Dipoli before the implementation of other less desirable renovation plans in 2015-2016. Here, the same case study is written for the second time.[7] By rewriting the same case, this case studies chapter aims at reflecting deeper insights into the topic of design for sustainability targeting issues of reverse salients. In the earlier paper, the insights were drawn from transitions and strategic design literature, yet were not consolidated as a design approach proposition as such. Now, with the proposition (as proposed in Chapter 2), this second discussion of the causal relationship between the insights and case study is substantially deeper and hence captures new insights. In this chapter, the empirical data and findings presented in the earlier paper are maintained because they are the foundational research evidences. However, they are rephrased with the aim of deepening and yielding further empirical evidences to enrich the theoretical insights.

4.1.1 The case: renewable energy transitions applied to deploying solar photovoltaic in built heritage

The transitions situation in this case study, in which design engaged in the investigation of the initial proposition, resulted from a contingent opportunity. This contingent opportunity was the installation of solar photovoltaic (PV) modules on a heritage building on a university campus as part of a renovation scheme that aims to achieve the energy vision of the campus: “energy self-sufficiency vision by 2030.” Even though it would serve to fulfil this vision, any large-scale and sudden installation of solar arrays is clearly not suitable for a heritage building. The vision would thus evidently involve tense strained opposition between heritage value and energy efficiency. As a consequence, it would be easy to dismiss the viability of the entire idea of campus reform for energy self-sufficiency. Problems inherent in the near-future consequences need to be carefully tackled early on before they impede solar

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[6] The design exploration was advised by Professor Sampsa Hyysalo and done in a team led by me with two design researchers, Jenni Väänänen and Namkyu Chun, of Aalto University, Helsinki. In the leadership role, I made plans for the whole design process, including the application of research methods. During the process, three of us worked in a team to conduct the literature research, field work, solar array design through to technical analysis relevant to analysing solar energy efficiency for Dipoli. During the process, I identified several key informants and captured crucial information from them during interviews, which were of pivotal importance to the success of this project.

[7] After the project, Professor Sampsa Hyysalo and I finished the case study in a journal paper discussing the integration of transitions insights with strategic design for sustainability. This paper, titled “Designing for Energy Transition through Value Sensitive Design”, was co-authored by us and published in 2017 in the international academic design journal *Design Studies* (Mok and Hyysalo, 2017).

installation in similar built heritage and hamper the overall renewable energy development in Finland with disastrous consequences. Foreseeing unfavourable near-future occurrences in short-term planning, this case of heritage renovation is appropriate for design to investigate the design proposition of mitigating the future adverse results before those outcomes lead renewable energy systems in an undesirable direction.

In this case study, the technology design framework of Value Sensitive Design (VSD) was adopted. The framework specialises in technology design for value investigations and it was adopted because the complex conflicting values involved in this case study require a methodological approach to deepen value understanding. The design process in this case study follows the VSD approach, staged in three parts of value investigations. To be clear, VSD in this case study is used to assist the discovery of values in systems, while the design approach proposition remains the central focus of investigation of this case study.

This solar energy transitions case was situated in socio-technical systems that co-evolve with societal and technological development. The penetration of intermittent renewables in Finland is relatively low compared to its Scandinavian neighbours in spite of the country's commitment to reducing carbon emissions by 2020. The carbon emission per capita in Finland is in the mid-range in global terms with an annual reduction trend of 5-7% due to its Arctic location and intensely cold weather, which results in high energy and heating consumption (Environmental FI; Motiva, 2017). In spite of the committed targets to increase the share of renewable energy in electricity production – for example, wind energy (4.6% in 2016) and solar energy (0.06% in 2016) – the adoption of these cleaner technologies by Finland remains slow. The price of the solar photovoltaic (PV) module has been falling worldwide during the past few years; in Finland, PV has reached grid parity in both household and industrial systems and, in addition, transmission network fees or taxes are exempted in personal use (FinSolar, 2015). However, being hampered by a lack of net energy metering (NEM) or feed-in tariff (FIT), import taxes and bureaucracy involved in solar PV systems installation have made PV expansion slow in Finland (Šúri et al., 2007; Pasonen et al., 2012; FinSolar, 2015). As a corollary, this low solar market penetration has led to relative inefficiency in solar PV module consumption and installation. The soft costs of solar in terms of installation service fees account for more than half of the price of a physical solar module and installation, which is also twice as high than in Germany (FinSolar, 2015). These have daunted Finnish solar energy development.

Changing the situation requires niche alternatives to grow into a salient to advance into socio-technical regimes. However, producing a transition to replace the dominant socio-technical regimes requires strategic efforts to break through the established incumbency in large socio-technical energy systems (Geels, 2002; 2006; Geels and Schot, 2007; Grin, Rotmans and Schot, 2010:1-8). To create opportunities to break through, niches must gradually overcome problems in transitions. However, problems in new systems development are dampers that inhibit niche solutions from advancing into the established systems environment. This is due to the fact that the systems environment has been determined to favour the dominating regime. Initiatives are ongoing to tackle this case of renewable energy transitions in Finland: for instance, documenting evidence of installation costs to combat uncertainty and scepticism regarding lower prices, expanding import tax-excepted systems, developing aids and services to assist energy calculation, such as solar yield, solar module and installation services costs, standardising permits across municipalities to ease installation and so on. However, the transitions situations – comprising multifarious activities in systems – will not be eliminated by any one measure, even though the steady annual drop in the price of solar modules supports solar energy transitions. Rather, any single measure would be likely to be held back in transitions due to socio-technical interdependencies in the systems.

Even complex, future contingencies of systems dynamics in the transitions context arise in situations, which Hughes (1983) has highlighted as reverse salients – the inverse of a salient that resembles the fallen section of advancing niches that would impede the overall growth of new systems. This is due to unseen problems inherent in the near future or problems that, even if they are foreseen, cannot be easily tackled (Hughes, 1983:79-105). Wind power installation in Finland has severely been curbed by resistance to the landscape effects – landscape change and wind turbine noise (Korjonen-Kuusipuro and Janhunen, 2015). The same may be true of solar PV installation. In this case, it is foreseeable that some city planners, conservation architects and citizen groups will be sceptical about the suitability of modern solar technology on heritage building rooftops. It is also foreseeable that solar installation companies are incompetent in displaying the visual qualities of solar installations on cultural heritage buildings, which may easily result in a lack of aesthetic quality. As a consequence, the Finnish energy system might easily revert to using non-renewable fossil fuels. If this issue is unaided by guidelines, it is likely to create reverse salients in the form of a categorical rejection of installing renewable energy across all built heritage. This background poses challenges to design to investigate how to mitigate the predicted unfavourable results, which in due course might prevent Finland from advancing solar energy.

The empirical setting to explore new strategic design is a renowned architectural heritage building in Finland called Dipoli, used to advance solar photovoltaic (PV) installation in built heritage. Dipoli was designed by Reima and Raili Pietilä in the 1960s. The building was situated on the campus of Aalto University, which is currently undergoing extensive renovation, under the strategic plan of Aalto University's campus reform aiming to achieve its "energy self-sufficiency vision by 2030."

4.1.2 The Value Sensitive Design (VSD) framework for value investigations

Due to the complex conflicting values involved in this case study – cultural heritage preservation, ecological modernisation and the aesthetic quality of preserved heritage – the technology design framework of Value Sensitive Design (VSD) is adopted in this case to assist value investigations (Friedman, 1999; Friedman, Kahn and Borning, 1999; 2002; 2013).

Value Sensitive Design (VSD) is a framework to guide design of technology with a focus on the value dimensions of design work. The framework discovers values that are sensitive not only to human values, such as human welfare, privacy and trust, but also to environmental sustainability values (Friedman, Kahn and Borning, 2013). It handles values through its theoretically and methodologically grounded approach, which is described as an integrative tripartite methodology involving three parts of investigations – conceptual, empirical and technical investigations – and it is used in an iterative manner (Friedman, Kahn and Borning, 2002). In this manner, values are investigated, prioritised and evaluated backward and forward iteratively throughout the design process and the findings of each phase guide each other. This approach aims at arriving at a technology design that eventually supports ethical values, as our case concerns environmental sustainability. VSD originates in the field of design of information and computational systems in the 1990s, exploring values in large-scale systems of high complexity, which can be adequately applied in this energy transitions case that involves complex multiple value conflicts (Friedman, 1999; Friedman, Kahn and Borning, 2002; 2013).

Design research also includes methods supporting human values and ethics, such as participatory design. However, an approach like VSD that explicitly explores values and technology in large-scale systems and a variety of contexts is more appropriate and sufficient for this energy transitions case (Borning, Friedman and Kahn, 2004). The VSD framework has been applied to many empirical studies to demonstrate how to engage VSD in design, such as cases exploring cookies and informed consent in web browsers (Friedman, Kahn and Borning, 2002), interface design for a large-scale urban simulation system (Davis, 2006), ethical values in nanopharmacy of new drugs (Timmermans, Zhao and van den Hoven, 2011) and moral, ecological and aesthetic values in a wind energy project (Oosterlaken, 2015). These add practical insights to enhance the value investigation process in this case study. Furthermore, it has been developed through discussions and evaluations for theoretical development throughout the research community (for example, Dantec, Poole and Wyche, 2009), even including self-reflection (Borning and Muller, 2012). Due to its established theoretical foundation and methodological strengths for technology design in large-scale systems, as discussed, VSD is deliberately chosen to guide the exploration of values underlying this energy transitions case. The tripartite methodological process is explained in the following.

As introduced, VSD consists of three parts of investigations: conceptual, empirical and technical investigations. Conceptual investigations aim at revealing and clarifying fundamental issues underlying cases. The investigations explore both explicitly supported values and inherent stakeholder values. Simultaneously, both direct and indirect stakeholders are considered, along with their respective values including value tensions and trade-offs, in addition to their interests. In this conceptual phase, methods like document analysis, literature review or tools of stakeholder mapping are used to assist conceptual analysis. At the end of conceptual investigations, a priori values are identified, analysed and prioritised. Empirical investigations emphasise contextual exploration to observe and measure activities while stakeholders are interacting with the technology. During empirical investigations, alternative technology design concepts could be explored and evaluated with stakeholders. Moreover, values are further articulated by stakeholders when they encounter alternative technical choices (Borning et al., 2005). To enable stakeholders to articulate their views, several case study methods are applied, including observation, on-site prototyping and interviews. By the end, both a priori values and empirical findings are connected for evaluation to formulate criteria to guide technology design. The last phase of technical investigations focuses on the technology itself. The investigations examine and analyse properties of the technology; additionally, statistical calculation is helpful to support technological properties. Technical findings are used to support the values identified in the previous phases, while simultaneously the previous value investigations are used to guide the conception of technology design. In this integrative and iterative approach, the final technology design could be supportive of the committed values, which results in a more desirable value-sensitive design (Friedman, 1999; Friedman, Kahn and Borning, 2002; 2013).

To deepen value exploration, a flexible investigation arrangement in this energy case study was attempted, which was also suggested by later VSD theorists and writers (Borning and Muller, 2012; Le Dantec, Poole and Wyche, 2009). In this case, the architectural literature in conceptual investigations and technology experimentation in empirical investigations were integrated due to the need to consider heritage values and potential damage to heritage values from solar installation that requires back and forth argumentation. These two value findings were iteratively reviewed and analysed. Afterwards, technical investigations were followed to realise the design.

4.1.3 The design process

The design process in this case study followed the VSD framework staging with three types of value investigations, which is the distinctive tripartite course of VSD. A diagram is drawn up to illustrate the three types of value investigations of the VSD approach for the present case study (Figure 5. The VSD framework in tripartite process used in the present case study). While following the three value investigations, the central focus of investigation in this case study of the design approach proposition comprises the five theoretical insights – (1) analysing transitions from a multilevel perspective, (2) identifying reverse salients, (3) correcting reverse salients, (4) setting guidelines for actions, and (5) demonstrating the feasibility of the solutions.

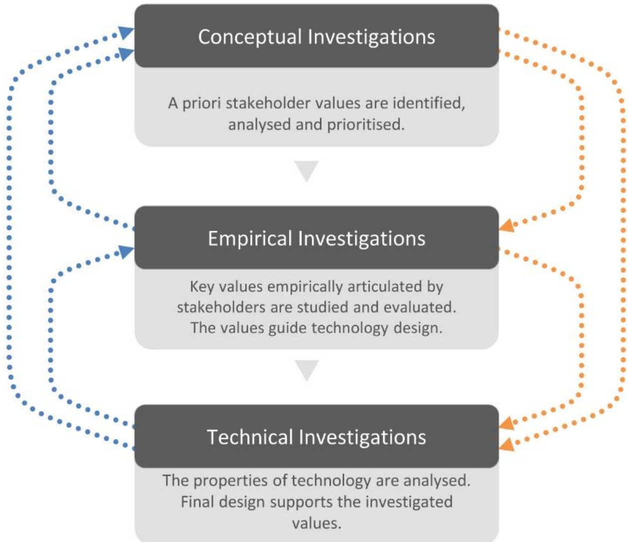


Figure 5. The VSD framework in tripartite process of Conceptual, Empirical and Technical Investigations used in the present case study.

Conceptual investigations

Conceptual investigations explored both explicitly supported values and inherent stakeholder values in the Dipoli renovation case. At the beginning, several key explicitly supported values are evident. The first key value is *cultural heritage preservation* due to the historical importance of Dipoli and the fact that it was designed by renowned Finnish architects. The second key value is *campus prestige* because the renovation of Dipoli aimed to convert it into a main building for the campus, accommodating the University Presidency, Faculty Club and others, and planned to use it to bolster the university's image and reflect its mission. The third key value is *ecological modernisation,* as "energy self-sufficiency by 2030" is the campus vision. To realise this long-term energy vision, both ground source heat and solar would be the prime sources to be harnessed for meeting campus power and heat consumption requirements. However, the fact is that many buildings on the campus are preserved, which implies the need to exploit the rooftops of these heritage buildings to generate solar PV energy. Therefore, failure to demonstrate the viability of siting solar PV on Dipoli would restrain broader-scale rooftop solar installation on the wider campus. To achieve this energy vision, it is necessary to reconsider if these preserved buildings could be used and, if so, in what ways they should be used. The last key value is *economic and space viability* for generating renewables feasibly.

These four explicitly supported values were explored and seemingly conflicted with each other. To preserve cultural heritage in the strict sense of restoration would exclude any idea of modernisation of the building and its uses, which would prevent any solar technology installation. The aim of increasing campus prestige would certainly require functional changes, even opening up the rooftop for new activities, which would be likely to lead to rejection of solar construction and also potentially damage heritage values. Economic and space viability in turn might, on one extreme, suggest a merely symbolic adoption of solar on the premises that is not incorporated into the historical architecture at all, which environmentalists might call greenwashing. On the other extreme, maximising the yield of solar energy in the name of ecological modernisation to achieve the energy vision would result in a severe loss of both aesthetic quality and heritage values, and the university would thus gain a bad reputation for ecological brutalisation.

After identifying the explicitly supported values and explaining their potential value conflicts, the next step is to investigate the inherent stakeholder values. The stakeholders are from a diverse range of different domains, with varied interests, priorities, solutions as well as visions about changes in the future (Smith, Stirling and Beckhout, 2005; Geels, 2010). This implies that the potential conflicts amongst different stakeholders may even be aggravated. At this stage, the analytical tool quadrant stakeholder mapping was applied. Both direct and indirect stakeholders related to this energy transitions case involving the Dipoli renovation were plotted along with their key and corresponding values, including both interests and their extent of power (Friedman, Kahn and Borning, 2013). Their values were analysed through the process of comparison between stakeholder groups. Afterwards, the map listed several key direct stakeholders: *Aalto University Presidency*, *Aalto University Properties* and the *solar technology providers*. The *architect constituency* – including some architects in the renovation project and the National Board of Antiquities – is also plotted as a key direct stakeholder. Their expert opinions on the preservation and modernisation of Dipoli would definitely have a strong influence on the issue of solar installation. *Students and alumni* of Aalto University are listed as interested but less powerful stakeholders.

The explicitly supported values and inherent stakeholder values investigated in conceptual investigations are put together for value prioritisation to identify benefits or harms of installing solar PV on Dipoli from the perspective of each stakeholder group. In prioritisation, the greatest priority should be given to those who are strongly affected, even if they are indirect stakeholders (Friedman, Kahn and Borning, 2013). By this consideration, the technology design would not be biased towards only key and direct stakeholders while ignoring strongly affected but indirect stakeholders. This value-sensitive design approach fosters an equilibrium amongst the investigated competing values that would be needed for a working solution. Here, the greatest priority was given to the *preservation* and *modernisation of heritage* while considering *aesthetic quality* and *functional quality* in terms of the efficiency of costs and energy of the building. The last value was the aim of establishing a *university identity* as an environmentally conscious and prestigious educational institution.

VSD conceptual investigations have assisted in identification of key stakeholders and the prioritisation of their inherent values. At this stage, transitions analysis was also conducted to explain the situation of renewable energy transitions applying to Dipoli's renovation. Using the MLP analytical framework, the analysis configured and explained the dynamics of transitions engendered from the interferences of elements and activities in this socio-technical energy system from a systems perspective. In the configuration, diverse elements and activities on different levels were mapped and the identified key stakeholders investigated in the conceptual investigations of VSD were also charted on MLP for analysing niches projection in Figure 6. (MLP is adopted to analyse the renewable energy transitions applying to Dipoli's renovation).

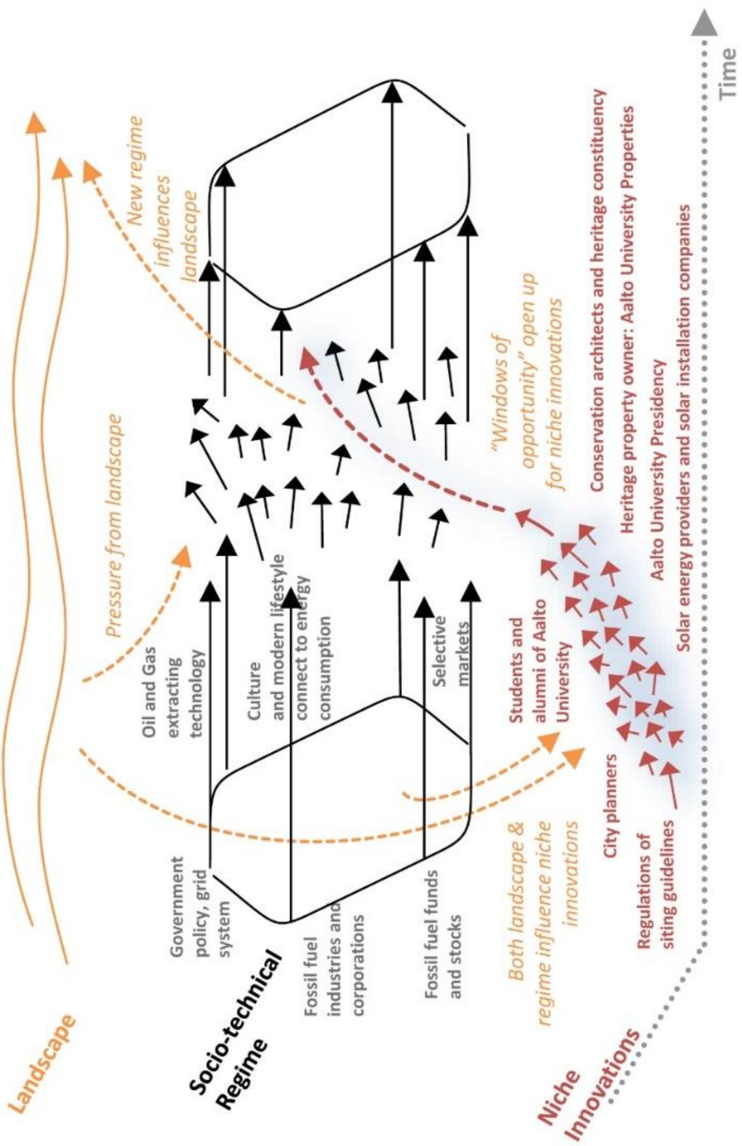


Figure 6. A multilevel perspective (MLP) on renewable energy transitions mapping the three levels of co-evolutionary activities with interconnected elements underlying systems and the niches projection, adapted from Geels and Schot (2007, p. 401).

Analysing from the MLP configuration, the socio-technical regime is identified as the current fossil fuel systems that are stabilised by numerous interlocking processes of elements and activities, such as fossil fuel industries, government policies, modern lifestyle connected to unsustainable energy consumption and many other processes interacting with each other. Niche innovations are represented by the identified key stakeholders whose niche efforts seek to break into the dominating systems. However, new systems growth may not be desirable due to issues of reverse salients developing in new systems growth. In this case, one reverse salient could emerge due to the scepticism of some city planners, conservation architects and citizen groups, who challenge the suitability of modern solar technology on heritage rooftops. Another reverse salient could be caused by the incompetence of solar installation companies that install aesthetically inferior PV on cultural heritage buildings, which results in the imposition of tougher restrictions on rooftop solar development. Transitions analysis examines niches projection and analyses reverse salients that may develop in the near future through exploring the interferences of processes within and between levels in systems. By this stage, VSD conceptual investigations have prioritised the following values of designing solar arrays for Dipoli: *preservation and modernisation* considering *aesthetic quality* and *functional quality,* and *university identity*. These values are now empirically investigated to arrive at empirically grounded values.

Empirical investigations: a historical inquiry into heritage value

Regarding the three prioritised values – *preservation and modernisation* considering *aesthetic quality* and *functional quality* and *university identity* – there is a need to understand the heritage value of Dipoli that has evolved over time. The key direct stakeholder – the architect constituency with a strong influence on the issue – and the indirect stakeholder – students and alumni of Aalto University who are strongly affected by the issue – are investigated for empirical insights.

Dipoli was designed by the Finnish architects Reima and Raili Pietilä (1923–1993, 1926–, respectively). It was a design concept that won the vote from students in an architecture competition held in 1961 (Johansson, Paatero and Tuomi, 2009). The building was inaugurated in 1965 and later converted from a student venue to a commercial congress centre due to financial difficulties in the 1980s (Quantrill, 1985; Aalto University, 2014). It was bought by Aalto University Properties several years ago and a renovation plan 2015-2016 was initiated in collaboration with the National Board of Antiquities.

Over the past half-century, modifications were made to Dipoli. The paper published earlier on this case study chronicled the architectural conversions made to Dipoli over the years to implement functional and design alterations (Mok and Hyysalo, 2017). At the beginning, the student union office was located in Dipoli and the function of the building was to house both student activities and conferences. During 1966-81, continuous minor design alterations were made to the building for maintenance purposes. In 1981, Dipoli was converted into an international conference centre. The office of the Student Union was moved out and student activities were prohibited. Due to the change in its function, design alterations were made to the building, including wall colour, flooring materials, staircases, the blocking of some windows, and so on. Later in 1993, the function changed again when the number of international conferences declined due to the economic depression and Dipoli became a congress and training centre. Since then, alterations have been made not only to implement functional changes but also to address changes in the surrounding context. In 2010, the ownership of Dipoli was transferred from the Student Union to Aalto University. In 2014, it was bought by Aalto University Properties, which initiated a renovation plan. A plan view shows the modifications that have been made to Dipoli since 1966 (Figure 7).

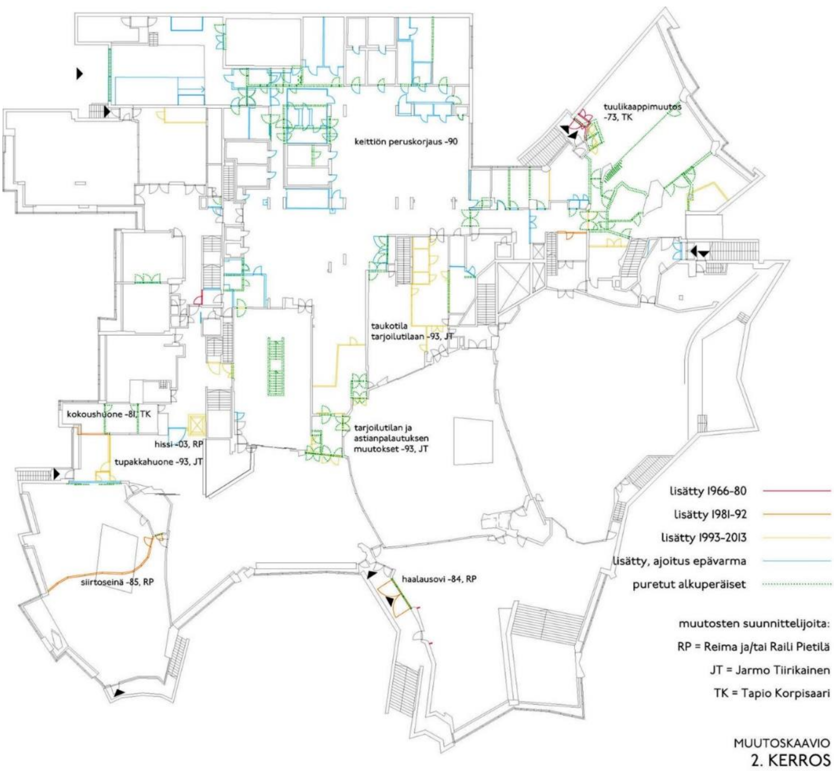


Figure 7. A plan view shows the modifications that have been made to Dipoli since 1966 (Arkkitehtitoimisto ALA and Vesikansa, 2015 and published in Mok and Hyysalo, 2017).

Fully aware that the heritage building had evolved over time, the architectural value existing from the beginning was also revisited in order to help judge the optimal claim to preservation. Dipoli was envisioned as a multifaceted architectural experiment – one of its most significant aspects was the concept of *environmental experiment*. The concept aims to explore the interaction between the building and its surrounding environment (Hansen, 1967; Kultermann, 1967; Norberg-Schultz, 1967;

Pietilä & Paatelainen, 1967). The experiment resulted in engaging the surrounding natural landscape with Dipoli while at the same time hiding Dipoli in the pine forest (A+U, 1974; Johansson, Paatero and Tuomi, 2009) (Figure 8).

Figure 8. An aerial view of Dipoli (centre, left). Photo by Martti I Jaartinen, 1966/1967 (from the archives of the Museum of Finnish Architecture, the MFA, 1967 and published in Mok and Hyysalo, 2017).

Another significance of Dipoli's origin as an architectural experiment is that it has a dual character. The northwest part of Dipoli was designed to be angular in terms of its geometry, while the southeast part was free form. Its contradictory and imbalanced exterior together with the uncontrollable contours of the roofscape were harshly criticised. In spite of the criticism, Pietilä argued back that it was his rational intention to feature both functional and expressive concepts (A+U, 1974; Johansson, Paatero and Tuomi, 2009). The roofscape was also claimed to mimic the underlying contours of rock and to represent a dinosaur's silhouette (Quantrill, 1985) (Figure 9). Pietilä's overall design of Dipoli has conveyed both Finnish localness and international modernism (Johansson, Paatero and Tuomi, 2009). As stated in a review, being appropriately modern is important to Pietilä (Quantrill, 1985). The subtle and delicate concept of defining modernity offers rich insights into modernising Dipoli.

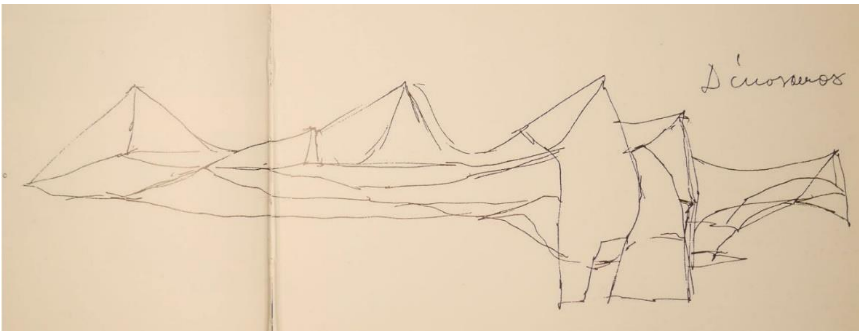


Figure 9. The dinosaur's silhouette by Pietilä (Quantrill, 1985 and published in Mok and Hyysalo, 2017).

The understanding of the architectural value of Dipoli – evolutionary changes of Dipoli over time and interacting with surroundings – as being appropriately modern has provided rationales to modernise it by preserving its heritage value as an environmental experiment evolving and interacting with its surroundings. The several key architectural values have also provided crucial evidence to unfold the perceptions held by the heritage constituency about Dipoli.

In an interview, a key legacy holder of Pietilä architecture states that Dipoli could be modernised if the solar PV is installed aesthetically in a way does not ruin the roofscape silhouette:

> *The roof of the Dipoli is a very important element of the building ... of course there are areas of the roof on which you could not place a [solar panel] installation without them ruining the silhouette ... It is all right as long it does not ruin the valuable building's architectural appearance – the very reason that the building is a heritage building* (Interview with a key Pietilä architecture legacy holder, 16 November 2014).

However, a professor of architecture developing the campus felt that the idea of installing solar PV in Dipoli was unfeasible due to his view that the copper rooftop is inaccessible:

> *"I'm afraid that the thought of installing solar panels on Dipoli is a dead-end thought because of the architectural value of the building ... Otaniemi is full of anonymous, mediocre brick buildings. There would be no harm in covering them with solar panels ... This sounds fun and dangerous simultaneously. Hopefully she [the researcher of this case study] really has a permit to enter the fragile copper roof and insurance!"* (Email correspondence with a professor of architecture, 15 November 2014).

In addition, an architecture researcher who was commissioned to make a heritage preservation study of Dipoli was interviewed. He envisioned that, conceptually, Dipoli was designed to feature a full copper roof, which implied absolute heritage preservation without any solar installation. When the plan was aimed at renovating Dipoli to a more acceptable and sustainable building, while also considering other stakeholder values, the preservation of Dipoli by restoring the building to its original concept should not be considered the optimal way. In fact, it is also arguable that the roof was never too fragile to walk on. Since the construction of the building in the 1960s, all flat surfaces were covered with bitumen felt topping with gravel for waterproofness and cost-efficiency. Due to the technological limitation that bitumen felt could not cover slopes, at that time only non-flat surfaces including the slope band, skylight boxes and small ventilation boxes were covered in copper sheet. This rooftop material differing from the original design concept had Pietilä's approval. In 1986, the entire roof area had already been covered with new bitumen felt, including the non-flat surfaces, and without a gravel top due to technological advances. Since then, unrestricted access to the roof has been granted. Figures 10 and 11 (in Table 6 below) show the Dipoli rooftop in 1967 and 2014.

Table 6. A history of Dipoli's rooftop referring to its preservation values.

	Conditions

Figure 10. Photo of Dipoli taken in 1967 by Martti I. Jaatinen (image from the archives of the Museum of Finnish Architecture, the MFA, 1967 and published in Mok and Hyysalo, 2017).

1965:

- All flat surfaces were covered in bitumen felt topping with gravel.
- Non-flat surfaces (the slope band, skylight boxes and small ventilation boxes) were covered in copper sheet.

1986:

- All surfaces were covered with new bitumen felt (photo not available).

Figure 11. Dipoli's entire rooftop was covered with bitumen felt; photo taken on 13 November 2014 (from Mok and Hyysalo, 2017).

2015:

- A photo was taken by the time the renovation plan of Dipoli was initiated. The photo shows the entire roof was covered with bitumen felt.

Source: *Arkkitehtitoimisto ALA and Vesikansa*, 2015.

Moreover, the opinions held by the architects regarding the preservation and restoration of the heritage building have disregarded the continuous alterations that have been made to Dipoli over time, even during the time of construction in the 1960s. During its construction, the original concept was altered as agreed by Pietilä, as mentioned above. Another significant characteristic of the building – the way in which it engages with the surrounding pine forest – has already changed, as the forest was gradually replaced by birches, car park and twenty tall flagpoles with colourful university flags standing outside the building. Investigating the architectural values of Dipoli, one conclusion is that Dipoli was planned from the outset to evolve over time with its surrounding environment. That being so, inheriting the architectural values of Dipoli legitimises its modernisation when the changes are done with careful consideration. Dipoli thus evolves over time, being appropriately modern.

The opinions of the architects likely set up reverse salients that might be accepted by Aalto University Properties. If so, there was a need to intervene by bringing forward issues of reverse salients to the forefront and furthermore by providing an alternative solution for siting solar on Dipoli before other less desirable renovation measures were proposed.

Empirical investigations: field observations and interviews on solar energy siting

Empirical investigations emphasise contextual exploration to observe and measure activities while stakeholders are interacting with the technology. In these investigations, field observation was conducted to explore the surrounding context with Dipoli. In addition, on-site prototyping was done by trialling a real rooftop PV on Dipoli to explore the interaction between stakeholders and solar technology.

In the real context, putting real PV panels on the Dipoli roof and conducting on-site interviews aimed at eliciting stakeholders' views on various solar options. The realness of the prototyping helped engage stakeholders for their further articulation of a solar array. Fifteen Dipoli visitors were interviewed at the entrance of Dipoli; in addition, five interviewees were located at the cafeteria on the second floor inside the building (where the two ends of the roof are visible through the cafeteria window). Most of the interviewees were engineering and architectural students of the university. The picture below recorded the on-site prototyping experimentation of placing solar panels on the roof at 45 degrees to leave them subtly visible (Figure 12).

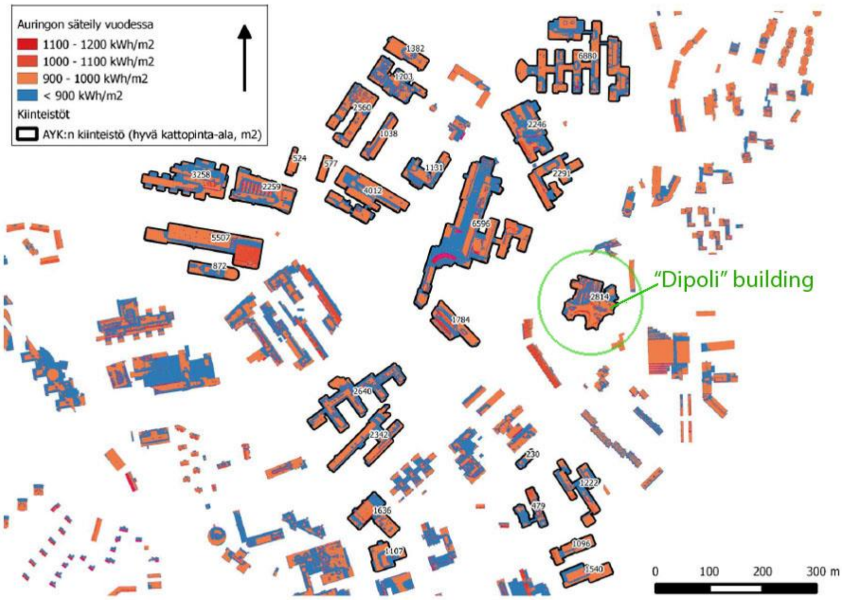
Figure 12. The prototyping experiment view of solar panels placed on the rooftop at 45 degree angles, which left the view "subtly" visible (from Mok and Hyysalo, 2017).

In the interaction of solar technology with fifteen interviewees, none of them found the solar installation disturbing; rather, they welcomed having a solar installation on Dipoli. They further expressed that having the solar PV visible on the rooftop could build an eco-conscious identity for the university. Some also described Dipoli as a modern building, which implies that people's perception of what is modern encompasses not only the modernist style but also contemporaneity with the present time. Amongst the fifteen interviewees, around one-third expressed their concern about aesthetic quality when siting solar in Dipoli.

At the end of the empirical investigations, the empirical findings about stakeholders' views on various technical options were connected to the a priori values prioritised in the conceptual investigations. The key values are formulated as criteria to guide technology design in the next step: (1) to achieve *preservation* yet *modernisation* with consideration of visibility of the rooftop solar PV panels and modernity of Dipoli, (2) to build the eco-conscious *identity* of Aalto University and, finally, (3) to consider the *environmental importance* of producing renewable energy in an appropriate way to yield meaningful energy production, neither greenwashing nor ecological brutalisation. These key values are now used as criteria to guide technical investigations.

Technical investigations

Technical investigations examine and analyse properties of the technology. In these investigations, statistical calculation including technical and costs data on energy usage and solar technology is conducted to support technological properties. To summarise, from the internal Report of Energy Self-Sufficient Otaniemi (Aalto University Properties, 2014), the target for Dipoli's energy production is set on the basis of total solar energy production on the Otaniemi campus, 16.4 GWh/year; based on data from the solar irradiance map of Otaniemi campus, 1,000–1,200 kWh/m2/year is the optimal solar radiation range recommended for PV panel installation (Figure 13), and the given total roof area of 5,554 m2 facilitated solar coverage calculation, balancing energy efficiency and suitability to the architectural and aesthetic quality of the buildings. Moreover, the Photovoltaic Geographic Information System (European Commission Institute for Energy and Transport, n.d.) recommended an optimal panel-tilt angle of 35–45 degrees for the best possible capacity in Helsinki, and additionally provided the simulated energy yield. Also, the statistical analysis of the energy consumption figures for Dipoli during 2009–2014 provided by Aalto University Properties indicated that a mix of solar PV and solar heat collectors would be preferable. In addition, the costs data provided by the leading Finnish solar panel producer, including PV costs per watt, the infrastructure set-up and maintenance costs helped prove economic viability.



Kuva 8. Aurinkoenergian tuotantoon parhaiten soveltuvat kattopinta-alat AYK:n kiinteistöissä Otaniemessä.

Figure 13. A solar irradiance map of Otaniemi Campus, Aalto University (Report 2014, p. 22).

Last, before creating the optimal solar design solution, a further assessment was made considering the minimum energy yield, conversion loss from DC to AC as well as a proportion of solar panels and collectors suited to Dipoli's electricity consumption practices. Finally, it was suggested that a total of 277 PV panels should be installed, yielding total energy production of 160,326 kWh/year by covering 557m2 of the 5,554m2 roof area. Of this total sum, we further advised a combination of 216 solar panels covering 432m2, which would yield 64,800 kWh, and 61 solar collectors covering 122m2, which would yield 95,526 kWh for collecting heat. Due to the drop in the price of solar panel units while this case study was conducted, a 15-degree angle could viably be used (instead of the optimal 45-degree angle) as this would diminish yield by only 10–15% due to the possibility of closer positioning of the PV racks. This flatter assembly clearly offered a more suitable alternative with respect to the aesthetic of the Dipoli roofscape. After all, we created the design solution with a view to ensuring that presenting the number, position, direction, angle and arrangement of panels would be suitable to the Dipoli renovation.

4.1.4 The strategic design result: the strategic visualisation

Guided by the three investigations, a value-sensitive design solution was created. The three committed values – preservation yet modernisation with consideration of the visibility of solar PV in Dipoli and its modernity; environmental importance yielding meaningful energy production, neither greenwashing nor ecological brutalisation; and an eco-conscious university identity – guided the working compromise between the conflicting values. The solution is neither a fully visible installation nor fully invisible, but instead represents a concept of subtle visibility. This concept of subtle visibility means that the solar array becomes visible when approaching Dipoli at a distance of 100 metres away from the entrance at ground level. This fulfils the criterion of environmental importance and corresponds to the university's eco-conscious identity. Moreover, introducing sustainable renewable energy with a subtle concept does not damage the heritage value, but rather maintains the continuity of the building's function. Furthermore, the carefully worked-out solution makes Dipoli evolve in step with contemporary requirements, in line with Pietilä's design principle in which the environment is important for being modern appropriately. The diagram below illustrates the integrative and iterative process of the VSD tripartite course under study (Figure 14).

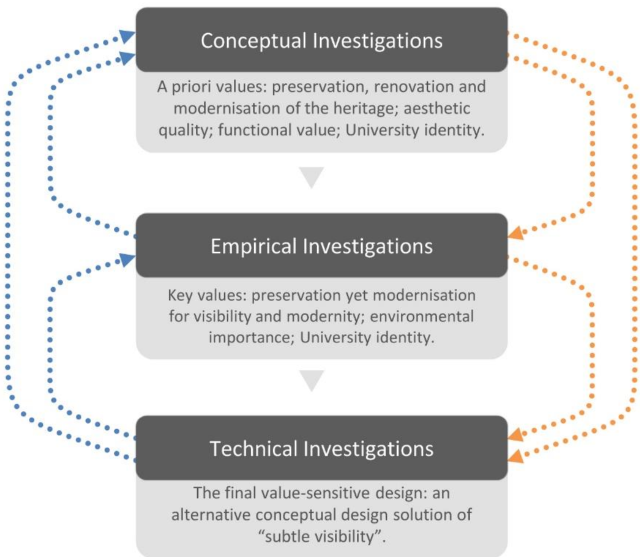


Figure 14. The VSD technical design supports the investigated values (from Mok and Hyysalo, 2017).

The design concept of subtle visibility generated a set of architectural renderings with a high degree of clarity and resolution (Figures 15–19). These renderings were provided to Aalto University Properties as guidance to further expand the project and a demonstration for other similar projects of siting solar energy in heritage buildings on the campus. The City of Espoo has designated the study as being suitable for use as a project guideline for other similar sustainable renewable energy investigations in Finland. As a guidance or demonstration project, the study is not a final design solution. The high-quality visualisation is a strategic design tool in bringing forward issues of reverse salients to the forefront of solar energy transitions and furthermore offering a feasible alternative method for solar installation in heritage buildings.

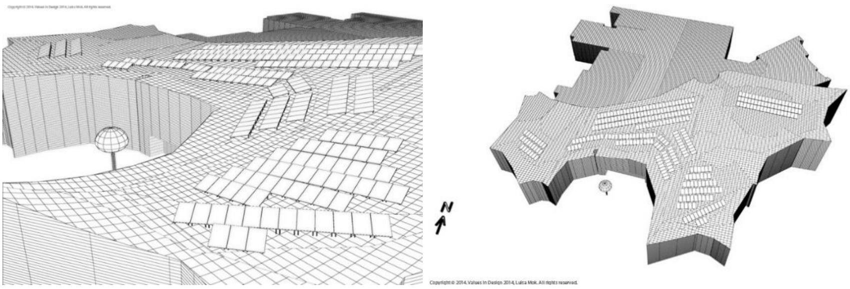


Figure 15. A realistic architectural rendering for visualisation and documentation as demonstration projects (from Mok and Hyysalo, 2017).

Figure 16. The solar array on the rooftop (from Mok and Hyysalo, 2017).

Figure 17. The solar array visible from the rooftop, viewed from another angle (from Mok and Hyysalo, 2017).

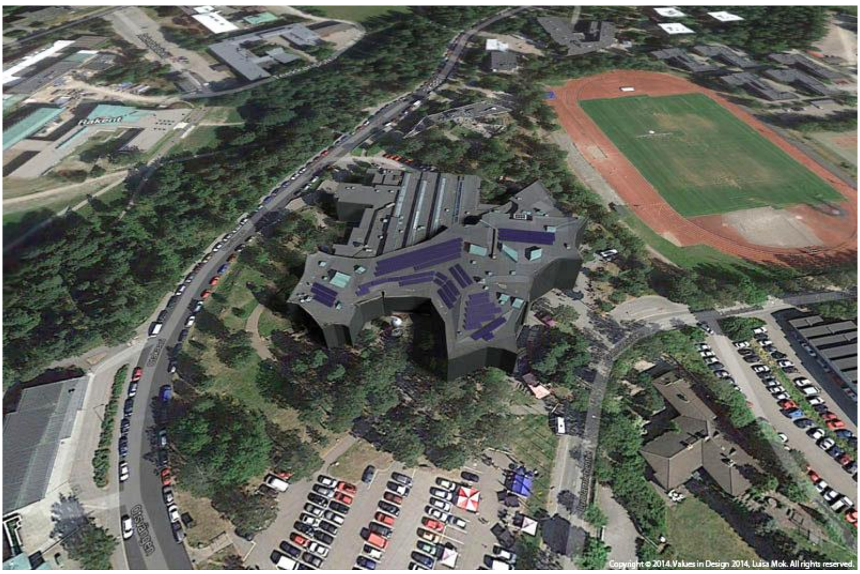


Figure 18. A bird's-eye view of Dipoli with the solar array (from Mok and Hyysalo, 2017).

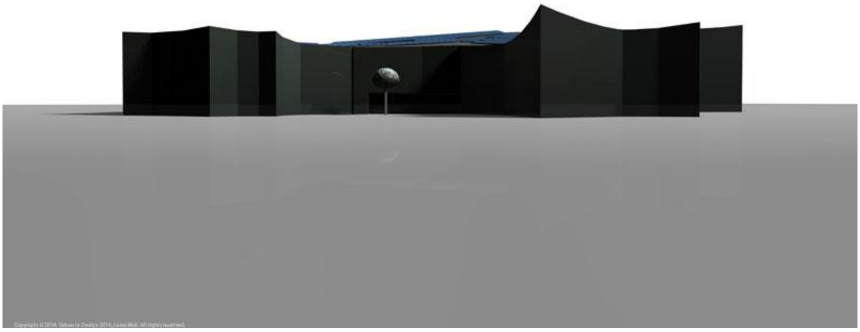


Figure 19. The view from 100 m away, the only distance from which the solar array is visible at ground level (from Mok and Hyysalo, 2017).

4.1.5 Within-case analysis to investigate the design approach proposition

This case study has described a design project to further renewable energy in Finland by adopting the design approach proposition that has been developed earlier. It is assumed that adopting the proposition in this transitions case would enhance design to create strategic design solutions for short-term future planning to mitigate future adverse circumstances. The purpose of this case analysis is to investigate the application of the proposition to determine whether it could enhance design for sustainability and further improvement. The evaluation is done through identifying the five design implications of the proposition from empirical observation and based on this to analyse the causal relationship between the theoretical insights and empirical findings.

The transitions situation under study is facilitating solar PV in built heritage, specifically a renewable energy transition applied to the Dipoli renovation case. By adopting the design approach proposition, the design process results in a set of strategic design visualisations (architectural renderings). The resulting design visualisation is "strategic" because it targets reverse salients – the adverse circumstances developing in the near future that may lead to disastrous consequences that eventually impede overall growth in renewable energy systems. To mitigate the reverse salients of other less desirable measures of renovating Dipoli that would lead to a categorical rejection of installing renewable energy in built heritage, an alternative design solution is created and, furthermore, it is operationalised to tackle the problems inherent in the short-term future. By adopting the design approach proposition, a new strategic design that connects the short-term future to the present-day importance of realising longer-term future visions is explored.

The design process began by analysing the transitions situation of deploying solar PV in a heritage building in its renewable energy systems. To comprehend the transitions, the MLP analytical framework is used to map and analyse the transitions dynamics of the situation. It maps and analyses the co-evolutionary activities with interconnected elements underlying the energy systems within and between levels. Analysing the future transitions projections identifies niche pathways for advancing solar PV in heritage buildings to achieve a breakthrough into the market dominated by non-renewable energy. The analysis is also aided by the VSD framework to discover values that need to be taken into consideration when deploying solar technology on the heritage rooftop. The identified key stakeholders and committed values are charted with MLP to aid in the analysis of niche projection. In the Dipoli renovation case, the heritage constituency and conservation architects are staunchly in favour of preservation of the heritage and would therefore categorically reject any form of ecological modernisation. Additionally, solar proponents – in this case, Aalto University Properties and solar technology providers – may not be competent to install solar PV for ecological modernisation, leading to a loss of aesthetic quality and heritage value. If the issue is not supported by deliberate guidance, it is likely to create reverse salients, causing deleterious effects that will impede overall solar growth, which might easily cause Finnish energy systems to return to fossil fuels. From the MLP analysis, an opportune point likely emerges when the values and activities of key stakeholders are aligned; however, conflicting values amongst them have displayed uneven quality of niches growth. This analysis of the transitions situation offers design a background understanding to explore problems of reverse salients.

In empirical investigations regarding the three prioritised values investigated in VSD and transitions analysis, an architectural review is conducted to understand the heritage value of Dipoli. The review also provides evidence to unfold the complexity of reverse salients. The reverse saliency of solar PV installation in this heritage building is reflected in the expert opinion held by the architectural professor, who claimed that the roof was too fragile to walk on. However, the fact is that the roof was only partially covered with copper sheet when it was first built and then, in the late 1980s, the entire roof area was covered with reliable roofing materials that have enabled complete access to the roof. That is to say, the roof was never too fragile to walk on. The reverse saliency of the issue is also reflected in the conservation architect's desire to restore the roof to its original state of full copper roofing. However, once again the fact was that full copper roofing was only a design vision of Pietilä – it has never been realised due to technical and costs constraints at its time. The opinion of the architectural professor and aspirations of the conservation architect reflect a major reverse salient in this Dipoli renovation case. They represent critical problems inherent in the near future that may lead to critical situations that will eventually hamper the energy self-sufficiency campus vision and lead to broader disastrous results that might cripple overall renewable energy transitions. Analysing reverse salients identifies the problems inherent in reverse salients – the experts' recommendations to Aalto University Properties on the renovation plans of Dipoli, which would lead to a categorical rejection of installing solar PV on Dipoli. In this sense, operational plans, typically prepared in a timely manner, are indispensable to practically eliminate critical problems.

The reverse salients of the aesthetic and heritage values that are not suitable for solar PV installation are defined as critical problems for correction. This energy transitions case addresses reverse salients that appear to be developing in the near future in transitions – the need to install solar technology across existing built heritage. The analysis of reverse salients defines the goal of the strategic design solution for short-term future planning. The goal is to demonstrate a practical solution for a working compromise between the investigated conflicting values – preservation, modernisation and aesthetic quality – when designing solar arrays for the Dipoli rooftop. The analysis also implies the critical timing of the solution, which had to be created before the experts made their recommendations regarding the renovation plans of Dipoli in 2015-2016, that is within one to two years.

To operationalise the strategic design solution in order to fulfil the goal of demonstrating a sensible way of installing solar PV in heritage, an alternative solution is offered. The resulting value-sensitive design is an alternative conceptual design solution featuring "subtle visibility" to modernise Dipoli. The design solution supports not only the committed values of preservation, but also modernisation for visibility and modernity, environmental importance and university identity. The solution created aims at guiding stakeholders to facilitate transitions and, to this end, guidelines are developed for Aalto University Properties. The guidelines are drawn up to demonstrate how to deploy solar PV on the Dipoli rooftop by presenting in high clarity the number, position, direction, angle and arrangement of panels suitable for the Dipoli renovation. As a demonstration project for not only Dipoli but also other built heritage across campus and furthermore other similar investigations into installing renewable energy technology in building blocks in Finland, the rationales behind the alternative solution are provided. This aims to show that the feasibility of the solution has been considered, thereby enabling stakeholders to make their own plans to facilitate renewable energy transitions. To do so, the feasibility of the "subtle visibility" design is supported by technical analysis and costs data to support technical and economic viability.

Conceiving short-term future projections furthermore demands high-quality visualisation. The specific visualisation quality is suggested as being the outcome of the qualities of concreteness, high-resolution, clarity, tangibility and realness. Regarding concreteness, the architectural rendering is well-defined by visualising the concept of subtle visibility from various angles. Particularly, the precise view of Dipoli from 100 metres away at ground level is shown to support the workable compromise of subtle visibility for ecological modernisation. The high-resolution rendering contains a large quantity of detailed information in terms of quantity of solar panels installed on the rooftop and their positions, tilt angles, directions, arrangement and so on. The high resolution is supported by thorough technical investigations into proving the viability of the suggested solar array. The visualisation is also rendered in high clarity to enhance comprehensibility of the issues and concerns involved in the alternative solution for Aalto University Properties and other solar technology providers. In addition, the visualisation is presented in a tangible format, which induces further articulation by Aalto University Properties for deliberating on their own strategies to facilitate transitions towards campus visions. Last, the visualisation is projected based on the present circumstances of the Dipoli renovation in its real context. This realness makes it easier for stakeholders to perceive foreseen future circumstances. Targeting short-term problems needs short-term future projections along with requisite visualisation quality to make the projections a reality as well as possibilities of tackling sustainability goals.

This case analysis has investigated the design approach proposition. The case does not aim at evaluating the VSD process. In spite of this, VSD has facilitated the discovery of values that are sensitive to human values including environmental sustainability. By committing to the investigated values, the final design results in a more value-sensitive design solution. The resulting alternative conceptual solution of subtle visibility suggests an equilibrium between preserving the valuable roofscape and yielding meaningful energy production without either greenwashing or ecological brutalisation. This informs solar proponents that siting solar in heritage buildings could be justified for ecological modernisation. This also shows to the heritage constituency that the dichotomy between solar technology and cultural heritage is misleading and impractical, and that solar could be functional and aesthetically constructed in heritage buildings when sited properly. Siting properly requires developing clear guidelines for the solution and providing rationales behind the solution. The need for guidelines and rationales implies that the concept developed in the Dipoli renovation case does not aim to present the final and only option for siting solar on a heritage building. Rather, by bringing the vision of reverse salients to the forefront, it allows anchored discussion among different stakeholders. If there is further development and implementation, the documentation offers guidance to deliberate on an optimal solution based on the considerations addressed in this project. A site where the design concept is demonstrated, complete with documented guidance (in the format of realistic architectural drawings), would make it easier for Aalto University Properties to expand solar energy siting on other campus buildings in order to achieve the campus vision of energy self-sufficiency by 2030. The City of Espoo has now designated the study for use as a project guideline that can be applied to other similar renewable energy investigations in Finland and scaling up if appropriate. The design solution is visualised and documented to demonstrate that it is untrue that siting solar in heritage buildings would violate heritage value. Aesthetic quality lies in attaining an equilibrium amongst different aspects in the transitions situation, and these aspects need to be identified and analysed carefully and properly to arrive at an acceptable solution.

Regarding the scale of the design intervention, the project scale in the Dipoli renovation case is set so as to gain a sufficiently large research scale to investigate the design approach proposition through exploring the possibilities of design to mitigate reverse salients for sustainability transitions. The result shows that even a relatively modest design project can facilitate systems transitions for sustainability.

Closing this within-case analysis, the case has identified the five design implications, which show a causal relationship between the theoretical insights of the initial design proposition and empirical data of the case. This suggests that each of the theoretical insights has played an active role in task completion. Altogether the proposition contributes to creating strategic design solutions for short-term future planning against reverse salients that are developing in the near future in transitions.

4.2 Case study 2: Designing for sustainable aquaculture transitions

The second case involves sustainable aquaculture transitions applied to Finnish salmon trout aquaculture in the Baltic Sea. The design exploration was done in spring 2016. Unlike the first case, which resulted from a contingent opportunity, this case was deliberately selected for the purpose of having different case studies, yet was designed to be comparable in order to improve the initial design approach proposition. This sustainable salmon trout aquaculture case was assigned by the Ministry of Agriculture and Forestry, Helsinki.[8] At that time, novel sustainable aquaculture technologies were readily available and supported by the Ministry; however, these were not being adopted by Finnish fish farmers. In view of this current impasse, it was an opportunity for design to explore possibilities of breaking the stalemate to stimulate development in Finnish sustainable aquaculture. The transitions case I was engaged in was part of the ongoing Finnish National Aquaculture Programme, which targeted doubling Finnish sustainably farmed fish production by 2020.

The same case study was rewritten for this dissertation with the intention of deepening the earlier concept of strategic design for sustainability transitions addressing issues of reverse salients.[9] The integrated knowledge – that is, the integration of transitions with strategic design insights – presented in the paper has now been organised in a design approach proposition (as proposed in Chapter 2). In this dissertation, the relationship between the design approach proposition and case study findings is discussed in greater depth and new insights into the topic are expressed. In this chapter, the foundational materials regarding the case background and empirical evidences are kept but rephrased for clarity and additional development in this subsequent work. To stress again, the application of the design approach proposition together with the discussion of this proposition and case study results are substantially developed from the earlier paper.

4.2.1 The case: sustainable aquaculture transitions applied to Finnish salmon trout aquaculture in the Baltic Sea

The current aquaculture systems in Finland are dominated by imported Norwegian farmed salmon, which was reported to account for 85% of the Finnish market in 2015 (Sandell, 2016). Other activities, such as farmed salmon production

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[8] During the research, I worked with the Natural Resources Institute Finland (Luke) in Turku, a research institute appointed by the Ministry to support the development of sustainable aquaculture in Finland. Luke provided research materials and information on current measures related to the development, but without interfering in my case study. To make it clear, I was the solo design researcher in this case study, responsible for the whole project from making plans, collecting, documenting and analysing data, analysing individual cases and comparing the two cases through to developing the final design solution.

[9] When I completed the whole project, Professor Idil Gaziulusoy and I finished the case study in a journal paper discussing the integration of transitions with strategic design insights, forming integrated knowledge to enhance design for sustainability. The paper, titled “Designing for Sustainability Transitions of Aquaculture in Finland,” was co-authored by us and published in 2018 in Journal of Cleaner Production, the international journal focusing on the topic of sustainability.

and salmon consumption behaviour, are also entrenched in the systems, which have stabilised the current regime of imported farmed salmon in Finland. To change the situation, the Finnish National Aquaculture Programme was launched with the aim of doubling Finnish sustainably farmed fish production by 2020. The programme is also part of the long-term EU vision of the Blue Growth strategy to promote growth in both marine and inland aquaculture (Eurostate, 2015; EU, 2016). This case concentrated on dealing with marine aquaculture for fish farming activities in the Archipelago Sea of the Baltic Sea.

To break through the current aquaculture regime, concerted niche efforts are required. These include, for instance, the identification of desirable water areas for siting fish farms in the outer Baltic Sea for offshore aquaculture; this was done in 2014. Moreover, a new concept for recirculating nutrients in the Baltic Sea was made available by the prompt launch of Baltic herring fishmeal production in Finland due to ecological concerns in 2016. In addition, there has been progressive streamlining of the fish farming licensing process in order to increase fish farming activities to boost industrial growth (Mäkinen et al., 2010: 45). Furthermore, the quota of the Baltic herring catch granted to Finland by the EU was increased, ensuring economic viability by farming the relatively high-value salmon trout with low-value native herring resources. These measures support sustainable aquaculture and have created an opportune time for the transitions. However, Finnish aquaculture transitions have remained slow.

In the 1980s, uncoordinated Finnish aquaculture practices caused severe environmental pollution in the Baltic Sea, leading Finnish aquaculture to a devastating decline (Saarni et al., 2003). Since then, years of historical events, the negative stigma of ecological destruction, social circumstances and industrial development have culminated in the regime of imported farmed salmon, which has made the revival of Finnish aquaculture difficult. Some environmentalists, summer dwellers and water recreationists would naturally disapprove of any fish farming activity in the Baltic Sea. Fish consumers might be sceptical about consuming fish farmed in the Baltic Sea, as they would assume that the water quality is bad. Even though the new concept of recirculating nutrients in the Baltic Sea is available, fish farmers may worry about whether the new fish feed would satisfy the appetite of the farmed fish as well as the effect on the taste of the fish for human consumption. Similarly, the identification of desirable water areas for siting fish farms in the Baltic Sea may not be supportive to the declining aquaculture industry, as seen from the meagre number of new fish farm applications. This low number could be accounted for by the stringent legislation governing fish farm licensing, which aims to strictly protect the water quality of the Sea but in so doing may also have stunted Finnish aquaculture growth.

In the co-evolving systems in addition to future contingencies of societal and technological development, changing elements embedded in systems dynamics would, at a particular time and space, potentially develop reverse salients – the future adverse results in short term (Hughes, 1983:79-105; 1986). If the problems inherent in reverse salients are not foreseen, this may lead to disastrous outcomes that will hamper overall new system growth. In this aquaculture transitions situation, one might logically presume that any increase in farmed fish production in the Baltic Sea would accelerate eutrophication in the sea. Without deliberate intervention to orient the transitions pathways, it could be impossible for the Finnish National Aquaculture Programme to achieve its production target by 2020. Setting up of reverse salients would further favour the market dominance of imported Norwegian farmed salmon. In the end, these make shifting to new systems even difficult. In this view, what is needed is to bring forward issues of reverse salients to the forefront of sustainable aquaculture transitions to inform how developing aquaculture could be done in sustainable ways to concurrently increase fish farming activities while also maintaining and improving the marine ecosystem in the Baltic Sea in the long term.

The new design approach proposition is applied to this aquaculture case study to explore the possibilities for design to mitigate near-future consequences in relatively large-scale systems transitions. The empirical setting for exploring new strategic design is the Finnish sustainable aquaculture systems applying to Finnish salmon trout[10] aquaculture in the Baltic Sea. The transitions case is part of the Finnish National Aquaculture Programme, which seeks to double Finnish sustainably farmed fish production by 2020.

4.2.2 The design process

This case study of sustainable salmon trout aquaculture transitions has been discussed in a previous paper, as mentioned earlier. The paper introduced a preliminary version of an integrated framework that integrates transitions insights and strategic design insights for tackling problems in transitions (Mok and Gaziulusoy, 2018). In the paper, three strategic design modes are presented by integrating sustainability transitions and strategic design studies. Reflecting on the preliminary version, the framework could have been improved in two ways. The first improvement is that the integration of the two sets of insights has not been fully expressed in terms of the depth of integration even though the insights derived from the literature review have a theoretical foundation. Due to this incomplete expression, some causal-effect relationships between the theoretical insights and empirical data are concealed. Therefore, in this dissertation, I did not use the presented integrated framework to discuss the case study for the second time. Rather, I returned to the original insights that were drawn from the two literature reviews – that is, before integration – and applied them to this case study. They are the insights contained in the initial design

[10] When discussing the Finnish salmon trout in the case study, it may be worth taking note of the fish species. In Finland, salmon trout rather than salmon are farmed because the cultivation conditions in Finland suit salmon trout farming (Saarni et al., 2003). Salmon trout refers to large rainbow trout that weighs from one to three kilograms. The name salmon trout aims to differentiate it from the commonly-consumed smaller size rainbow trout (0.2 – 0.5 kilograms) in other European countries.

approach proposition summarised at the end of the literature review (Chapter 2). Afterwards, the empirical evidences will be tied with the five insights to capture a deeper view in preparation for building a refined design approach. The second improvement is that the term "unforeseen" is not clearly explained in the paper, and this might be misleading. In the paper, there are two places using the phrase, "to mitigate unforeseen problems and facilitate transitions towards sustainable futures" and "brings unforeseen problems to the forefront of aquaculture transitions" (Mok and Gaziulusoy, 2018:135). That said, the two instances of "unforeseen" in the paper imply problems inherent in the near future that are not foreseen (that is, problems of reverse salients that may impede new systems growth) instead of any problem that is not foreseen by people. However, the term "unforeseen problems" still needs to be rephrased to avoid making a misleading statement. Having explained this, the sentences should be made clearer, as follows: to mitigate future adverse results through strategic design by bringing problems inherent in the short-term future to the forefront of transitions due to their present-day importance towards realising sustainability futures, which is the central value of this doctoral research.

Responding to the two criticisms and for the intellectual development of this dissertation, improvements are made. First, the design approach proposition containing five distinctive theoretical insights that are respectively drawn from transitions literature and strategic design literature before their integration is adopted in the case. Second, the design task is phrased as targeting problems inherent in the short-term adverse future. These are problems that may develop into adverse future circumstances leading to disastrous outcomes that impede overall transitions. After clarification, the proposed design approach comprising five insights to target problems in reverse salients is articulated. The investigation is discussed below and the five theoretical insights are – (1) analysing transitions from a multilevel perspective, (2) identifying reverse salients, (3) correcting reverse salients, (4) setting guidelines for actions, and (5) demonstrating the feasibility of the solutions.

Analysing the transitions situation: the conceptual transitions analysis

As suggested by the initial design approach proposition, this case study analysed the specific sustainable salmon trout aquaculture transitions situation in Finnish aquaculture systems and adopted the multilevel perspective (MLP) analytical framework for analysis. Mapping the three systems levels – the socio-technical landscape, socio-technical regime and niche innovations – reveals the multifarious interferences of elements and activities in the systems (Figure 20. Multi-level perspective (MLP) analysis of the Finnish salmon trout aquaculture transitions).

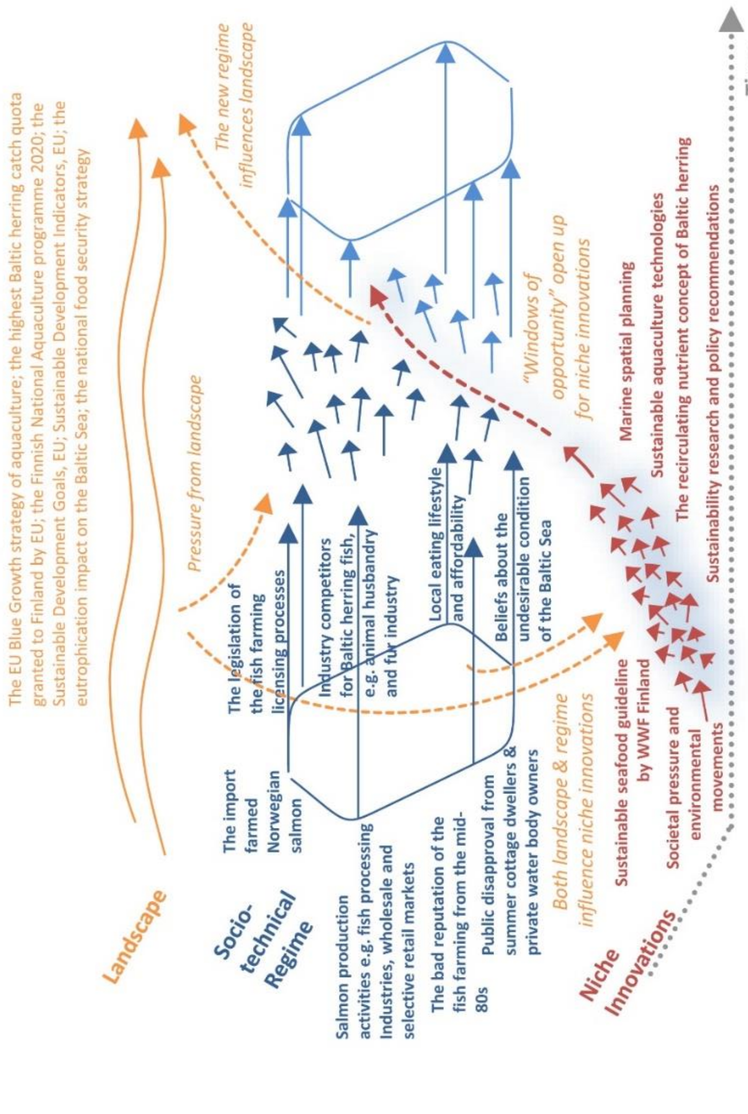

Figure 20. A multi-level perspective (MLP) analysis of the Finnish salmon trout aquaculture transitions that maps the co-evolutionary dynamics and trajectories of the regime and the niche pathway projection, adapted from Geels and Schot (2007, p. 401).

The macro level of landscape does not directly influence activities of the other two levels in systems but has provided the context for how the two levels respond to pressure for transitions. At this level, the production target of the Finnish National Aquaculture Programme 2020, the highest Baltic herring catch quota granted to Finland by the EU and the longer-term goals of the EU Blue Growth strategy of aquaculture have exerted huge pressure on the dominating regime of imported farmed salmon as well as the locally farmed salmon trout niche. Other longer-term visions like the Sustainable Development Goals and Sustainable Development Indicators of the EU have also put pressure on the two levels. In addition, there is considerable stress from minimising the eutrophication impact on the Baltic Sea and securing the Finnish food supply. The meso level of the socio-technical regime is analysed to be the dominating import of farmed salmon. In the goal-seeking systems, the paths are entrenched by activities that favour the dominance of imported Norwegian farmed salmon in the Finnish market. Production activities, such as fish processing industries and wholesale and selective retail markets, together with the consumption activities of local fish eating lifestyle and affordability, reinforce and stabilise the imported farmed fish regime. The stabilisation of the regime is also attributable to the legacy of the bad reputation of Finnish aquaculture practices, which caused severe water pollution. As a consequence, the perception of undesirable water quality has steered consumers' dietary habits towards imported fish. Additionally, there is strong public disapproval towards increasing fish farming in the Baltic Sea. Even more disadvantageous is the stringent fish farming legislation that as a consequence severely restricted local aquaculture growth (Setälä et al., 2012; AVI, 2016). Lacking a supply of sustainably and locally farmed fish further strengthens the imported farmed fish regime. These mutually reinforcing activities amongst the elements stabilise the dominating systems and cause lock-in complexes that have made shifting to new systems difficult.

The micro level of niche innovations projects the concurrent niche efforts from various stakeholders that tend to shape the transitions pathways towards breaking the imported salmon dependencies. When placing the projection of the niches under scrutiny (Figure 21. A delineation of the multiple societal and technological trajectories towards aquaculture sustainability), it illustrates the development of various stakeholders who put efforts into making progress towards the sustainability goal of increasing farmed salmon trout production by 2020.

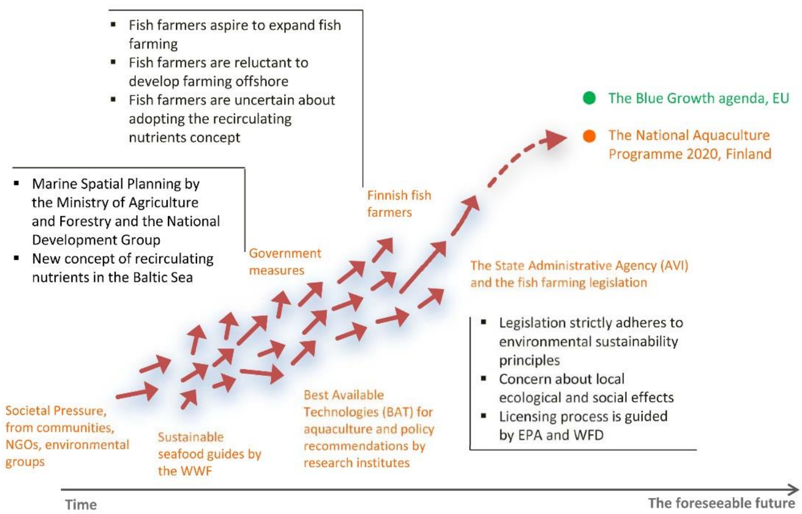

Figure 21. A delineation of the multiple societal and technological trajectories towards aquaculture sustainability through the multiple efforts of key stakeholders (from Mok and Gaziulusoy, 2018).

The relevant niche efforts are: several major sustainable aquaculture technologies include the recirculating nutrient concept supported by Baltic herring fishmeal production, which offers justification to fish farmers to increase fish farming in the Baltic Sea. The Marine Spatial Planning of the Ministry of Agriculture and Forestry identifies desirable water areas for siting fish farms in the Archipelago Sea of the Baltic Sea, thereby ensuring good water quality for fish farming. The AVI for Southern Finland approves fish farming licences according to the national and EU directives with a view to minimising eutrophication effects in the Baltic Sea as well as local ecological and societal effects, which ensures sustainable fish farming. Fish farmers and the Finnish Fish Farmers' Association seek to increase farmed fish production by updating their fish farming practices. WWF Finland launched sustainable seafood guides in 2016 to promote sustainable salmon trout consumption and production in Finland. Being a neutral organisation, WWF also advises fish farmers and the Ministry of Agriculture and Forestry about sustainability measures in Finland and guides consumers in making sustainable fish consumption choices.

Now MLP has mapped not only different activities at each level but also identified many processes that interfere with interconnected and interdependent activities. The niche efforts have presented a convergence of initiatives towards the 2020 goal. However, salmon trout aquaculture transitions have still been slow in Finland, while the Norwegian farmed salmon market is aggressively growing in the Finnish market. Analysing from the configuration, neither the recirculating nutrients concept nor Marine Spatial Planning to minimise the eutrophication level in the Baltic Sea have been adopted by fish farmers. On the one hand, developing sustainable aquaculture without adopting the recirculating nutrients concept and offshore fish farming by fish farmers would definitely accelerate eutrophication in the Baltic Sea. On the other hand, the production target will not be achieved without siting any fish farms in the Baltic Sea, which would favour the import of Norwegian farmed salmon. This current impasse may easily develop reverse salients in the near future, which would as a result lead to failure to achieve the production target and furthermore reinforce the import of farmed salmon. Having a conceptual understanding of the transitions situation, the next step is to identify and analyse critical problems inherent in reverse salients.

Identifying and analysing reverse salients: empirical investigations

After analysing transitions, we carried out empirical investigations to understand the actual transition situation. The empirical investigations include a field observation and several interviews with key niche stakeholders that were analysed from transitions analysis.

A field visit was arranged by Luke, the research institute responsible for sustainable aquaculture in Finland, for me to join a local fish farm company at its fish farms in the Baltic Sea. The field work was undertaken in May 2016, which marked the beginning of the Finnish salmon trout farming cycle. The field site was located in the southern Baltic Sea in the Archipelago Sea, 22.6 km offshore from Brändo in the region of the Åland Islands. The site was exactly located in the officially identified "good" water area for fish farming under Marine Spatial Planning by the Ministry of Agriculture and Forestry (Figure 22). In the interview with the fish farm manager, she explained that locating farms offshore involves high investment and management costs due to their remoteness and weather challenges. This revealed that fish farmers are mostly unwilling to develop aquaculture in offshore areas, as evidenced by the handful of applications for the four selected offshore sites under Marine Spatial Planning (AVI, 2016). The site consisted of three sea cages with a total production of 210,000 kilograms of farmed salmon trout in 2015 (Figure 23). The amount was far too insignificant for meeting the 2020 double-growth target. To meet the target, approximately 400 additional fish farms of a similar size would be required in order to yield a total of 28 million kilograms (mil kg) production (total Finnish salmon trout production was 13.9 mil kg in 2015) (Setälä et al., 2012). For feeding, the fish farmers used fish feed imported from Chile that contained non-native ingredients. The non-native fish feed violated the closed-loop ecological system, but fish farmers argued that its advantages are its stable cost and quality, which suits the preferences of the farmed salmon trout and has a favourable effect on the taste of the farmed fish (Figure 24).

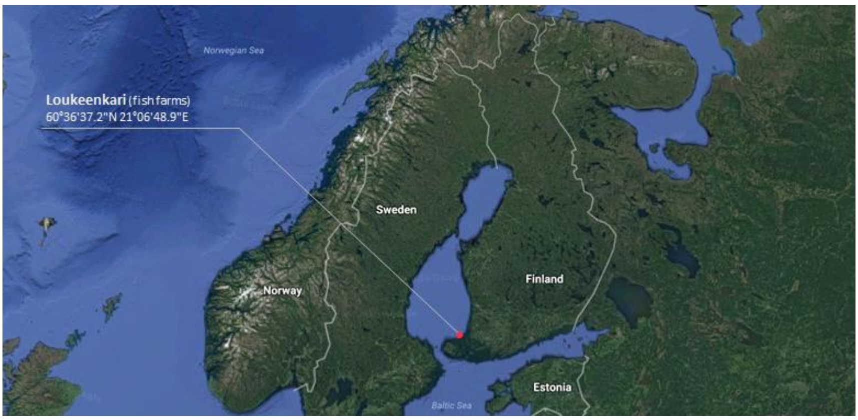

Figure 22. The fish farm under field observation is located in the "good" or "very good" water areas in the Baltic Sea off South-West Finland that are identified as desirable for aquaculture by Marine Spatial Planning (from Mok and Gaziulusoy, 2018).

Figure 23. The offshore fish farm under field observation in the Archipelago Sea of the Baltic Sea, photo taken on 24 May 2016. The site consisted of three sea cages with a total production of 210,000 kilograms of farmed salmon trout; however, meeting the 2020 double-growth target would require 400 additional similar-sized farms.

Figure 24. A feed blower emitting fish feed pellets that are imported from Chile, to feed farmed salmon trout at a fish farm in the Archipelago Sea of the Baltic Sea. Photo taken on 24 May 2016 (from Mok and Gaziulusoy, 2018).

Targeting production growth, Luke proposed a production allowance with the use of a specified new Baltic herring fishmeal as an incentive scheme (Mäkinen et al., 2010). However, as expressed by the fish farm manager, fish farmers were reluctant to accept it due to the limitations involved in the use of the fishmeal (fish farm manager, 2016). During an interview with the Managing Director of the Finnish Fish Farmers' Association, this unanimous view amongst fish farmers was plainly explained by the fact that this new fish feed has an exclusive supplier, which has caused uncertainty about future fishmeal costs among fish farmers (Finnish Fish Farmers' Association, 2016). There is only one fishmeal supplier because the presently small aquaculture industry in Finland cannot afford more fishmeal factories (Setälä, 2016). This created a vicious circle in which demand for Baltic herring fishmeal is low due to the small scale of locally farmed salmon trout production at present, resulting in relatively high and unstable feed costs.

In the sustainable seafood guides published by WWF Finland in 2016, Finnish-farmed salmon trout and whitefish were categorised as green, which means they are favourable to eat (WWF Finland, 2016a). The tight Finnish environmental legislation has regulated Finnish salmon trout farming to produce healthy farmed fish for consumption – they are free from sea lice and disease (WWF, 2016b). This has enabled Finnish aquaculture to gradually recover from its past stigma. However, this tight environmental legislation was also reflected in the stringent fish farm licensing; during the entire past year (2015), only one fish farm licence was granted by AVI, which has crippled the development of the industry.

The high investment costs due to remote offshore fish farm siting, uncertainty over the new fish meal costs and the stringent fish farm licensing discussed above have reflected the problems that have hindered the development of sustainable aquaculture in Finland. An even harsher impediment to the industrial growth of Finnish aquaculture is that Norwegian salmon farms are expected to be granted sustainable aquaculture certification in 2020 by the Aquaculture Stewardship Council (ASC), a non-profit organisation granting international accreditation for sustainable aquaculture under the strategy of the Global Salmon Initiative (GSI). The accreditation would further stabilise the highly organised and interconnected farmed Norwegian salmon regime.

While conducting this case study, some discoveries were made. In the meanwhile, the Finnish Baltic herring fishmeal producers were applying for certification from the Marine Stewardship Council (MSC), a non-profit organisation granting accreditation for sustainable fishing (Baltic herring and sprat were MSC accredited in June 2018, one year after this case study (Stenger, 2018). In parallel, the salmon trout fish farmers were also beginning to discuss applying for ASC certification. Attaining these two certifications should be expressed as the ideal objective for developing the new sustainable Finnish salmon trout aquaculture. However, in an interview, the Head of Programme of WWF Finland said:

> *Even I said the ASC is starting in Finland but it might not even happen. One reason is that the ASC does not have sustainability criteria for salmon trout farming in the sea as in the case of Finland that production is in the brackish open sea. Furthermore, Finland could be the only country having salmon trout production in the sea and, with her small amount of producers and production, it is not likely that the ASC would develop this new criterion. In the end, it might be problematic when farmers start to realise*

> *that Finnish salmon trout production might not fulfil ASC criteria.* (Interview with the WWF, 7 June 2017)

Desiring to be internationally accredited, however, Finnish fish farmers have never practically discussed the possible problems due to the lack of local ASC criteria for evaluating fish farming in the Baltic brackish open sea. This clearly indicates a reverse salient developing in the near future when the ASC result is to be released within a year, which becomes a critical factor that severely holds back the advancement of sustainable salmon trout farming.

Regarding the stringent fish farm licensing, an interview with the AVI for Southern Finland was conducted. The key notion suggested by the Director of Environmental Permits was that the AVI shared the common national production goal, yet environmental health was its foremost principle when granting a fish farm license.

> *To achieve sustainable salmon trout growth, the status of the Baltic Sea must be maintained or bettered. It is the principle of our legislation … There are more applications for coastal locations due to the lower investment costs … It is the responsibility of the fish farmers to develop aquaculture methods to minimise nutrient loading and make profitable investments*. (Interview with the AVI, 29 November 2016)

Fish farmers aspired to expand their farming operations; however, expansion could only be achieved by concurrently locating farm sites in the officially identified "good" or "very good" water areas in the outer sea and adopting the new Baltic herring fishmeal in order to assure the maintenance of the water quality. Based on these two necessary requirements, the strict licensing process guided by the environmental legislation of the directives of the Environmental Protection Act (EPA) and Water Framework Directive (WFD) (Ministry of Environment, 2016) does not diverge from the long-term national and EU environmental goals. Rather, the stringency of the licensing paves a path for salmon trout farmers to develop aquaculture in a sustainable way. Without such rigorous control, marine fish farming would easily revert to its history of industrial pollution.

The empirical investigations have identified several problems inherent in the near future that might develop into reverse salients that would impede the overall growth of sustainable aquaculture in Finland. The high investment costs in offshore fish farming, uncertainty regarding the costs of the new fish meal and the stringent fish farm licensing where only one licence was granted in one year have constituted the reverse salients leading to adverse conditions for the growth of new aquaculture systems. The most critical problem is that fish farmers aspire to secure ASC certification, but failure to achieve this would result in loss of momentum among fish farmers to grow sustainable aquaculture. The release of the unlikely-to-be-met ASC result within a year (before summer 2017) also indicates that an intervention to orient the transitions should be timed to occur within a year and also before ASC accreditation is granted for farmed Norwegian salmon in 2020.

Defining goals for short-term future planning

The analysis of reverse salients has informed the need for a solution to make fish farmers practise offshore aquaculture in the Baltic Sea and adopt the recirculation of nutrients concept. Furthermore, the solution has to be created within a year to mitigate reverse salients from developing in order to advance the new sustainable aquaculture systems. The empirical study also revealed the conflicting values amongst the key stakeholders. Fish farmers aspired to expand farmed salmon trout production but did not share the environmental responsibilities due to the high investment required by offshore aquaculture and new sustainable fish feed. However, in AVI's view, developing aquaculture methods to minimise nutrient loading to the sea should be fish farmers' responsibility. Rather, fish farmers put effort into applying for ASC certification without foreseeing the forthcoming results. Regarding consumption, the sustainable seafood guides published by WWF were instrumental in an advantageous position in informing and guiding consumers to adopt sustainable seafood choices. However, it may not have created sufficient pressure to exert tension on the regime of imported farmed salmon or cause changes in local fish consumption of locally and sustainably farmed salmon trout. Hence, the solution must be aligned with the Ministry's measures, AVI's fish farming legislation, fish farmers' responsibility as well as consumers' interests in local farmed fish to create an engagement site for concerted niche efforts. At the same time, the solution should also exert huge pressure on the regime, compelling it to make changes to respond. The solution created from the transitions analysis and empirical investigations to address issues of reverse salients is introduced next.

4.2.3 The strategic design result: the strategic certification

A conceptual design solution consisting of sustainable farmed fish certification, named the Finnish Ekofish Certification, is created to solve the problems inherent in the identified reverse salients – that is, the high investment costs of sustainable aquaculture. The certification is a national certification scheme deliberately targeted at local Finnish farmed fish and which is certified by the Ministry of Agriculture and Forestry and accredited by a non-governmental organisation. This certification scheme adopts the concept of transferability (Smith, 2007; Smith and Raven, 2012), which aims at shielding, nurturing and empowering the niche actors within the niches (Vergragt and Brown, 2004) before the new fish products are fully exposed to free market competition. The locally certified farmed fish, as a niche market, simultaneously makes use of the market mechanism to exert tension on the regime and adapts to the existing mainstream market. This aims at creating tension in the dominating system of the import of Norwegian farmed salmon through placing local farmed salmon trout on the market in order to eventually break through the regime (Smith, 2007; Smith and Raven, 2012).

The design concept of certification as a niche leverages niche-regime dynamics as the essential source for changes (Smith, 2007). Not only does it leverage actors as an essential driver of change, it also utilises market dynamics to enable both consumers and fish farmers to make informed (eco-)choices about consumption and production through the free market mechanism, yet within the protected certification frame (Kemp, Loorbach and Rotmans, 2007). As a result, it enables fish farmers and consumers to play active roles in a concerted effort to drive towards desirable future production and consumption habits. Positioning the certification at the niche-regime inter-levels furthermore sought an interfacing point where activities and elements in systems from both regime and niche-innovations levels for sustainable aquaculture transitions are aligned. This is where an opportunity is created for a niche breakthrough. In this way, solution goals are reflected by the shared interest between regimes and niches – in this case, consumers' interest in consuming sustainable fish as well as fish farmers' responsibility and motivation to produce sustainable fish.

Given niche space understanding, the certification is to be accredited by the local authority – it is suggested that this authority should be the Finnish Ministry of Agriculture and Forestry, which is responsible for the National Aquaculture Programme. This certification scheme included three essential elements: (1) a certification logo to establish an identity to facilitate campaigning and the rewarding mechanism, (2) a classification of eco-ratings and (3) a set of criteria for assessment. Figure 25 shows the essential elements contained in this certification scheme.

The three eco-ratings are Ekofish A++, Ekofish A+ and Ekofish A. At the same time, there are three principles behind the eco-ratings, which provide the reasons for the classification. The principles consider three sustainable aspects, including the well-being of ecology, humans and fish. Amongst them, the prime and foremost aspect is the prioritisation of ecological health, which means all eco-ratings should address this requirement. The three eco-ratings are:

Ekofish A++: must achieve the overall ecological, human and fish health requirements

Ekofish A+: must attain the ecological and human health objectives

Ekofish A: must meet the ecological health criteria

Ecological health requires (i) fish farmed in "good" or "very good" water areas in the Baltic Sea and (ii) the adoption of local fish feed, which means using ingredients native to the Baltic Sea. *Ecological health* forms the foundation for being certified as Ekofish in any class. The *human health* criterion defines that fish feed should not contain toxic ingredients, such as antibiotics. The *fish health* criterion is judged by the condition of the farming environment. A last measure is a measure of taste, related to the fish feed factor, which indicates that the sustainable fish feed should not compromise the taste of the farmed fish.

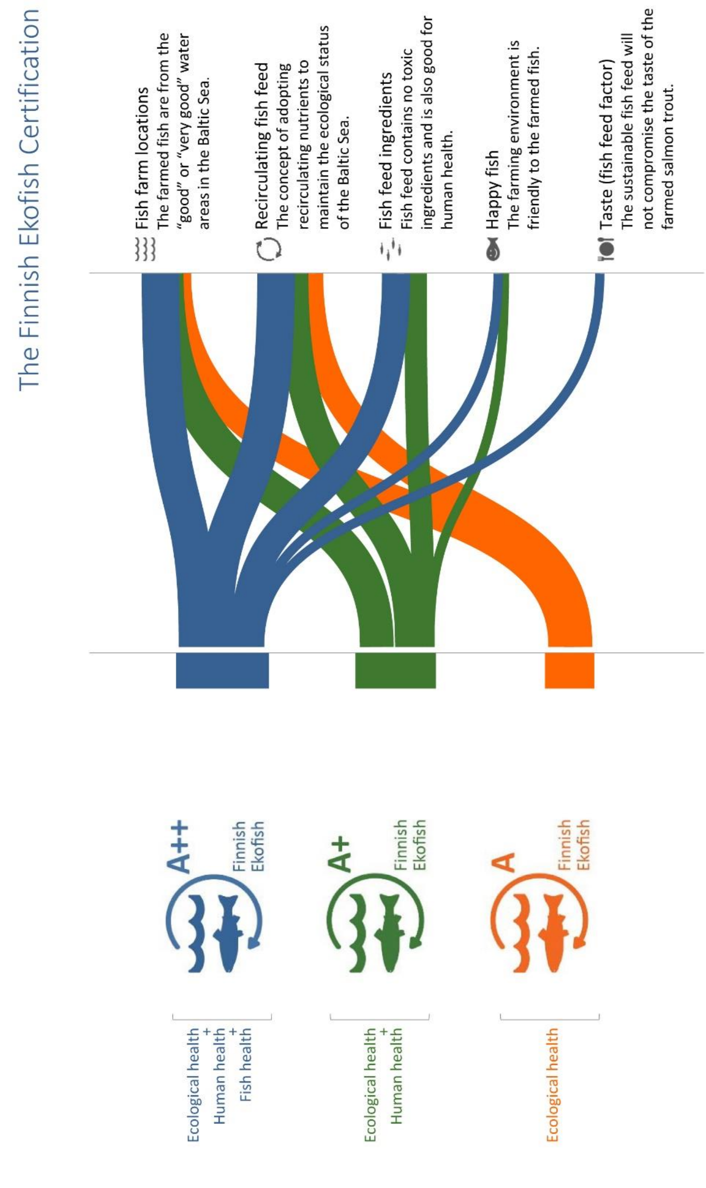

Figure 25. The resulting design of strategic certification, the Finnish Ekofish Certification, comprises three core elements: the certification logo, the classification of eco-ratings and the set of criteria for assessment (from Mok and Gaziulusoy, 2018).

In the certification system, all three eco-ratings (A, A+ and A++) require fish farmers to achieve the criteria of siting fish farms in more ecologically desirable offshore water areas in the Archipelago Sea of the Baltic Sea and adopt the recirculation of nutrients concept. The eco-rating principles are carefully set to tackle the future occurrence of either failure to achieve the production target when fish farms are not sited in the Baltic Sea or failure to maintain the water quality of the Baltic Sea due to improper fish farming practices. The first criterion spurs fish farmers to take responsibility for developing new farms in the open sea areas of the Baltic Sea where the water conditions are identified as “good” or “very good.” Hence, it increases their chances of obtaining new licences, which aims to accelerate the path of production growth. The second criterion directs farmers to adopt the recirculation of nutrients concept to minimise nutrient emissions. In the long term, this helps decelerate eutrophication as well as maintains and further improves the ecological status of the Baltic Sea. These two strategic principles are set to align with Marine Spatial Planning measures and the recirculation of nutrients concept. This certification sets guidelines as short-term goals for fish farmers to achieve. The principles – that is, the rationales behind the three eco-ratings – are also expressed in this visual form of certification.

The case study presented in this article is an actual part of the National Aquaculture programme (which will run until 2020) assigned by the Finnish Ministry of Agriculture and Forestry. The Ministry of Agriculture and Forestry, the AVI for Southern Finland, Luke and WWF Finland will elaborate and articulate the strategic certification design solution for further development and possibly implement the conceptual design. To be clear, the alternative conceptual solution does not aim to present the best or the only way to achieve sustainable aquaculture. Rather, bringing the vision of viable offshore aquaculture to the forefront enables concrete discussion of the solution, which includes the rationales behind the certification. This urges the key stakeholders to take action and develop their own ways to facilitate transitions towards achieving sustainability goals.

When the conceptual design solution of this certification was reviewed with the Ministry of Agriculture and Forestry, the AVI for Southern Finland, Luke and WWF Finland, they strongly agreed with it regarding its effectiveness in rectifying orientation towards achieving production goals (the review is documented). They analysed the effectiveness of this certificate with respect to providing a viable means to enable fish famers to act in accordance with the production goal, and recognised that the eco-rating principles offer fish farmers a justification to develop sustainable salmon trout aquaculture in response to the tight legislation governing fish farm licensing. By linking a solution to a market mechanism, the certification could create a new market for Finnish salmon trout and gradually enable it to compete with Norwegian farmed salmon (Luke, 2017). The certification is set up as an enabling platform to offer autonomy to fish farmers and aquaculture industries in order to expand their production quantity in line with their desires. When the representatives of the AVI reviewed the certification design, even though they uphold strict policies for fish farm licensing (as their position is to maintain the water quality of the Baltic Sea), they reflected that some changes in their environmental legislation might be necessary while conforming to the directives on environment and water (AVI, 2017). These discussions to a great extent have reflected that this short-term future projection of this strategic design has brought the visions of sustainable salmon trout aquaculture in the Baltic Sea to the forefront of transitions, when implemented in a detailed, clear and concrete manner.

As mentioned, this case study is an actual part of the National Aquaculture programme and the participation in the programme was assigned by the Finnish Ministry of Agriculture and Forestry. The resulting solution has not yet been implemented. Even though the solution has not yet been executed, the case study is considered successful insofar that it accomplishes the objective of developing a strategic design solution for short term based on the design model of Strategic Design for Short-term Future. The design solution is visualised and is at present under the discussion and review of the Ministry of Agriculture and Forestry, the AVI for Southern Finland, Luke and WWF Finland for a desirable plan to realise sustainable aquaculture futures.

4.2.4 Within-case analysis to investigate the design approach proposition

This case study explores new strategic design for the short-term future by adopting a design approach proposition. The initial design approach is expected to enhance design to create strategic design solutions for short-term future planning to mitigate adverse results in transitions. This section of within-case analysis details the individual case of Finnish salmon trout aquaculture transitions to investigate the application of the initial design proposition to determine whether it could enhance design for sustainability and further improvement. The evaluation is done through identifying the five insights of the proposition from empirical observation and based on this analysing the causal relationship between the theoretical insights and empirical findings.

In this case study, a strategic design is developed to intervene in the short term in order to facilitate sustainable salmon trout aquaculture in Finland. The resulting certification design is “strategic” because it targets reverse salients – the future adverse results developing in the near future in transitions that may impede overall sustainable aquaculture growth. To facilitate sustainability transitions, design intervenes to bring forward issues of reverse salients to the forefront of transitions and furthermore offers a solution to solve the inherent problems in the near future in order to mitigate reverse salients. In this case, the main problem inherent in the near future is identified as the high investment costs of developing sustainable aquaculture in the offshore Baltic Sea, which has daunted fish farmers and resulted in a stalemate in Finnish sustainable aquaculture transitions. What is needed is a design solution that offers fish farmers a viable option to invest in sustainable aquaculture by siting fish farms in the offshore Baltic Sea and adopting a recirculating nutrient concept by using the Baltic Herring fishmeal as an ingredient of fish feed for farming salmon trout. In this way, the fish farmers could facilitate their transitions by aligning them with the sustainable measures of the Ministry of Agriculture and Forestry towards the production target and even aligning their interests with the dominating farmed fish market. At last, the design solution indicates that developing aquaculture could be maintained sustainably and also improve the marine ecosystem in the long run. Through adopting the design approach proposition, this sustainable aquaculture transitions case has explored a new strategic design that connects the short-term future to the present-day considerations with a view to achieving a sustainable future in the longer term.

By adopting the proposed design approach, the design process begins from analysing the transitions situation of the Finnish sustainable salmon trout aquaculture transitions. In this case study, the MLP analytical framework is adopted to understand and analyse the current Finnish aquaculture systems from a systems perspective. The framework configures transitions dynamics by mapping the co-evolutionary processes and trajectories of interacting elements and activities within and amongst the three socio-technical systems levels. It maps the processes of the landscape that provides the context to enable Finnish sustainable aquaculture transitions, the socio-technical regime that is dominated by imported farmed salmon and niche innovations that develop local fish farming. In the analysis, an opportunity tends to be created for a niche breakthrough when the measures of the Ministry of Agriculture and Forestry, licensing requirements of AVI, aspirations of fish farmers to expand fish farming and interest of fish consumers in locally farmed fish are aligned. In this transition, sustainable aquaculture niche pathways emerge and their niche efforts have presented a convergence of initiatives towards the 2020 goal; however, the salmon trout aquaculture transitions indicate a reverse salient in the near future that apparently holds back the transitions.

The conceptual transitions analysis from MLP was followed by the identification and analysis of reverse salients. This step involves investigating problems inherent in reverse salients in order to avoid future circumstances that impede overall sustainable aquaculture transitions. The empirical investigations have identified several problems inherent in short term, which constitute reverse salients culminating in the current impasse. They are identified as the high investment costs in offshore fish farming and uncertainty concerning the costs of the new fish meal. In addition, the stringent fish farm licensing – as revealed by the meagre number of applications for new fish farms and the extremely low success rate – makes fish farmers feel that any future applications are futile. These have constituted reverse salients leading to adverse conditions for new growth in aquaculture systems. The most critical problem is reflected in the contemporaneous issue of fish farmers' prospects of success in the ASC certification of Finnish salmon trout farming in brackish open water. The prospect of the near-future announcement of the ASC's decision sparked alarm. Fish farmers anticipate it with enthusiasm, but have never practically discussed the difficulties in the application nor sought ways to make their own plans to share the sustainability responsibility to develop aquaculture in the Baltic Sea. These would set reverse salients of growing local sustainable aquaculture and in due consequence strengthens the dominance of imported Norwegian farmed salmon in the Finnish fish market. These nevertheless make shifting to new local sustainable aquaculture systems difficult. Together with the coming ASC accreditation of Norwegian farmed salmon in 2020, this would have a severe effect on the already stunted Finnish salmon trout aquaculture. Analysing reverse salients identified the problems inherent in reverse salients – the high investment costs of offshore aquaculture and uncertain fish feed costs, combined with the effects of feed on the quality of farmed salmon trout, which would lead to failure to achieve the production target by 2020. A solution is needed to solve this problem. The analysis directs a contingent intervention for design to engage at the right time, that is, before the release of the result of ASC accreditation.

Given this understanding, there is a need to urge fish farmers to shoulder their responsibility to develop their own best sustainable aquaculture plans. Orienting niches in line with strategic visions requires a short-term future projection to bring forward the visions of issues of future reverse salients to the forefront of transitions. In this transitions situation, this may offer fish farmers opportunities to invest in sustainable aquaculture in the offshore Baltic Sea as well as minimise nutrient loading in the sea to improve sustainability. The design approach proposition also indicates that it is vital to set guidelines when offering alternative solutions. The guidelines aim at prompting immediate actions from key stakeholders to avoid leading to further critical situations. This transitions situation strongly demands that fish farmers take action by investing and siting fish farms offshore and adopting the recirculation of nutrients concept. Furthermore, fish consumers' interest in consuming sustainable fish when the fish is available in the market is important. To facilitate actions from key stakeholders, the rationales behind the alternative solutions should be provided. Ensuring the viability of an alternative solution provides autonomy to fish farmers to devise their own strategies concerning their needs, methods and responsibilities in order to solve their own sustainability problems. Certification becomes a viable means to guide fish farmers' plans to engage in offshore farming investments, acquire technologies for sustainable aquaculture and overcome weather challenges to achieve the target.

Having defined the solution goal, including guidelines and justifications for the solution, furthermore requires a tactical engagement site to enable key stakeholders to act to facilitate the transitions. The design solution of the certification is positioned at the niche-regime inter-levels where shared interests between the regime and niche are aligned. The result of this certification scheme at the inter-levels guides fish consumers' (eco-)choice to consume sustainably farmed local salmon trout. Viability is also supported by the market mechanism wherein certification informs fish consumers that sustainably farmed Finnish salmon trout is available as an option and, to help increase acceptance, explains the reasons why trout is sustainable for consumption. This gradually adapts the Finnish farmed salmon trout to the existing mainstream market to create tension in the unsustainable aquaculture systems, eventually leading to a breakthrough into the dominant imported farmed salmon market. This is where an opportunity was identified and created for a niche breakthrough.

Targeting reverse salients, this strategic certification is conceived as an alternative solution for the short-term future. High-quality visualisation is required to ensure that the certification functions as intended. In terms of the quality of concreteness, the certification must be well-defined and highly precise when projecting the alternative solution. In this national certification, this precision is achieved by means of well-defined design elements comprising the certification logo, classifications of eco-ratings and the set of criteria for assessment. These design elements provide assurance on the feasibility of the certification scheme as an alternative possibility to pursue sustainability. The three eco-rating principles are precisely formulated to guide fish farmers to different targets, yet all three eco-ratings (A, A+ or A++) demand fish farmers to act in line with the sustainability measures of the Ministry of Agriculture and Forestry. The certification is also presented in high resolution and clarity in terms of detailing, intelligibility and comprehensibility for the design solution to be understood. It contains the necessary information and details to guide deliberation on adopting offshore aquaculture and new fish feed towards the production target. Concerning tangibility, the design is delivered in a physical form as a certificate, and as such is not an abstract conceptual solution at all. This enhances the visibility of new directions to fish farmers and fish consumers. The experiences of fish farmers and other stakeholders (including the Ministry, AVI, WWF, fish famers and fish consumers) with a physical certificate would spark practical discussions and thereby have an impact on new strategy. Last, the certification is projected based on present circumstances connecting to the realistic context of the existing fish market. This will ensure that fish farmers can more easily foresee future issues and their adverse effects than at present.

The alternative conceptual solution neither intends to present the final and only way to achieve offshore aquaculture nor creates a farfetched strategic vision at an abstract level. Rather, it is an actionable pre-plan for the near future. The pre-plan brings forward the short-term adverse future as well as an aquaculture vision to the forefront to enable fish farmers to realise that other alternatives are available to get into sustainable production. This enables them to target their present actions with the aim of mitigating the development of harmful occurrences in the near future in order to achieve longer-term sustainability goals. The design solution demonstrates one legitimate operationalisation of salmon trout aquaculture through an actionable strategic design plan for the near future. Furthermore, visualising issues of reverse salients enhances articulation and deliberation amongst the Ministry of Agriculture and Forestry, the AVI for Southern Finland, Luke and WWF Finland for their development of the Finnish National Aquaculture Programme towards the longer-term sustainability visions of the Finnish Blue Bioeconomy Strategy.

Using the design approach proposition in this aquaculture case, design is directed to identify, analyse and define problems inherent in reverse salients in systems transitions. In addition, to operationalise the planning in order to practically solve the inherent problems, the design solution visualises alternative potential solutions in high quality to clarify the goals, set guidelines and provide the rationales behind the solutions in order to produce a sustainable aquaculture transition. The within-case analysis closes this case study by confirming a causal relationship in the case – the five theoretical insights have played active roles in delivering their scopes of activities and the five insights as a whole enhance design to create strategic design solutions for short-term future planning to mitigate reverse salients in transitions.

4.3 Chapter summary

In this research, two case studies are used to investigate the design approach proposition that was developed earlier in Chapter 2. The case study results have demonstrated the relevance of the proposition to understand the specific transitions situation in each case and to develop and operationalise solutions for the short-term future. Case study 1 involves renewable energy transitions. In it, the proposition is applied to Dipoli's renovation to facilitate solar PV in built heritage. Case study 2 involves designing for sustainable aquaculture transitions. In it, the proposition is applied to Finnish salmon trout aquaculture in the Baltic Sea. The two transitions cases are deliberately chosen as case studies with a view to investigating whether or not adopting the design approach proposition would enhance design to create strategic design solutions for short-term future planning to mitigate reverse salients.

As a result of adopting the proposition, two strategic design solutions are developed for short-term future planning on the time frame of within one to two years before the situations become worse. The solutions mitigate future situations for transitions orientation by bringing forward issues of reverse salients to the forefront of transitions. Case study 1 develops a strategic design visualisation to show how solar can be installed in culturally sensitive ways in pursuit of ecological modernisation of a heritage building. Case study 2 develops strategic certification to show that aquaculture can be developed in sustainable ways to maintain and furthermore improve the marine ecosystem in the long term. According to the case results, a strong causal relationship between theoretical insights and case findings can be found in both cases, which confirms that adopting the proposition could enhance design to create strategic design solutions for short-term future planning to mitigate problems in the near future.

Before ending this chapter, two points must be restated. First, the design concepts generated do not aim at creating strategic visions on long-term projections that are oftentimes far-fetched. Rather, the significance of these two strategic design solutions are their operational importance in the present to solve problems inherent in the near future in order to mitigate reverse salients developing in the near future. This means that the two design solutions are strategic. Second, the design solutions developed in both case studies do not intend to present a final design solution that would be the only possible way to achieve sustainability futures. Rather, they are concrete, actionable short-term future plans to guide the actions of key stakeholders in the present to facilitate their own best plans for sustainability. In Case study 1, the demonstration of installing solar PV with documented guidance for strategic visualisation guides Aalto University Properties to expand the installation of solar panels on other campus buildings in order to meet the total electricity need on campus and achieve the campus vision of energy self-sufficiency by 2030. In Case study 2, the strategic certification guides fish farmers to invest in offshore aquaculture in order to increase their farmed fish production goal and meet the goal for this by 2020. These resulting strategic design solutions, after all, have both strategic and operational aspects for short-term future planning towards long-term sustainable futures.

At this research stage, these two case studies have explored a design approach proposition to pursue strategic design through an anticipatory yet operational concept, which targets problems in transitions that often do not as yet have immediate unfavourable effects but may lead to adverse results. The two resulting short-term future plans have operational importance in the present, as they address problems in transitions towards realising sustainable visions, which develops a new strategic design that connects the future to the present-day importance of the short-term issues. This suggests steps forward as an alternative perspective for a new design approach to sustainability transitions.

At the end, the design approach proposition applying to two case studies has established the internal validity of the research findings as reflected by the significant associations between the cause (the theoretical insights of the proposition) and outcome (strategic design solutions have been created). The next chapter puts the two cases together to analyse them in order to confirm that the theoretical proposition is applicable to explain both cases in terms of enhancing the development of short-term future planning against reverse salients.

5. Analysis of the two cases

This chapter analyses the application of an initial theoretical proposition to two case studies to confirm its sufficiency to identify and overcome problems emerging in the short-term future – that is, reverse salients. The two cases have been conducted earlier and described in Chapter 4. They are the cases of the renewable energy transitions applied to advancing the installation of solar photovoltaic in built heritage (solar PV in the Dipoli case) and the sustainable aquaculture transitions applied to Finnish sustainable salmon trout aquaculture in the Baltic Sea (salmon trout aquaculture case). The analysis puts the two cases together with the aim of confirming that the theoretical proposition is applicable to explaining each case in terms of their design processes, and thereby develop short-term future planning targeting problems in the short-term future. For the proposition to be applicable, the respective theoretical insights must have played their unique roles in each case to support the empirical outcomes of mitigating reverse salients. This indicates that pattern of relationships amongst the theoretical insights and empirical evidence within each case would be identified (Eisenhardt, 2007; Yin, 2014 [1984]). This may confirm that the proposition can be applied to other transitions cases in similar settings to achieve the development of short-term future planning to mitigate reverse salients. Besides comparing and confirming the case application results, the findings also serve to enrich and improve the initial proposition after being investigated with empirical evidence. After investigation, the empirically valid proposition will be developed into a genuine design approach for design for sustainability.

The case studies from the last chapter described the results of achieving the intended outcome of identifying and overcoming problems arising in the near future to mitigate reverse salients in sustainability transitions. Yet, both cases require further systematic analysis to discuss the significant associations between the cause (that is, the theoretical proposition) and outcome (that is, the outcome of developing short-term future planning) in order to conform the internal validity of the research findings (Cook and Campbell, 1979:37; Yin, 2014 [1984]). To establish internal validity, this section iteratively compares each case with the proposition. The assurance provided by a systematic analysis strengthens the causal relationships of how the theoretical proposition has led to the outcome of enhancing design practice for sustainability.

To establish external validity, the two cases are put together to compare and analyse the application of the proposition to cases. The most desirable outcomes are those empirically investigated theoretical propositions that can be generalised, that is, the results can be applied to other subjects and situations rather than being merely limited to the case studies conducted within the research (Kerlinger and Lee, 2000 [1964]). Based on a two-case study, this research does not claim generalisability of results. Rather, it stresses ensuring the iterative analysis of individual cases to strengthen the internal logic of the cause-effect relationship within these two individual cases. Afterwards, the analysis seeks to reflect patterns of cause-effect relationships across the two cases. This is the only means to identify important factors causing the recursive functions of the theoretical proposition to develop short-term future planning. By adopting a logical and systematic case-study procedure and rigorously justifying the results, this research expects that more and newer case studies applying the proposition will be able to produce the intended outcome of developing short-term future planning to mitigate reverse salients. In this way, the application of the theoretical proposition would subsequently be widened to sustainability transitions.

This two-case analysis is based on a rather small multiple-case study, a two-case study. Though a small case study, this chapter shows that analysis could also be carried out based on these two cases through a logical and systematic analytic process for confirming the applicability of the proposition to develop strategic design. This chapter has two main sections in addition to a chapter summary at the end. The first section, Section 5.1, discusses the analysis of the two cases. It is divided into two parts. Section 5.1.1 explains the analytic approach including the adopted case study logic, analytic strategy and tools in this analysis. Section 5.1.2 is the core of this chapter, which unfolds the entire analytic process of analysing the two cases. Afterwards, the second section, Section 5.2, draws conclusions from the analysis of the two cases to discuss how the theoretical proposition has been able to explain the two case studies. Equally as important, the new theoretical insights captured from empirical evidence are also discussed to improve the initial design approach proposition.

5.1 The theoretical proposition and empirical evidence

5.1.1 The analytic approach to analysing the two cases

To confirm the application of the proposition of enhancing design to the development of short-term future planning targeting reverse salients, this analysis puts the two cases, the Dipoli solar PV case and the salmon trout aquaculture case, together to discuss how each applies the theoretical proposition. The analysis seeks to reflect a pattern of causal-effect relationships between the initial proposition and case study data in the two individual cases. To proceed with the analysis, this section clarifies the analytic approach, including the case study logic, analytic strategy and some of the methods that are adopted in this analysis.

To reflect causal-effect relationships between the theoretical insights and empirical evidence (that is, case data) in both cases, those selected cases should possess comparable characteristics in order to enable proposition discussion with the ultimate aim of theory building from case studies (Eisenhardt, 1989). Case selection based on case selection criteria is essential to multiple-case analysis (Yin, 2014). In this case study logic, patterns across cases are expected at the outset of the case study procedure after case selection (Eisenhardt, 1989). In this research, the applicability of the proposition in the two cases is expected to be demonstrated through successive execution to develop short-term future planning. When analysing the two cases, predicted insights (that is, the theoretical insights) leading to the intended outcomes (that is, the resulting short-term future planning) are expected to be identified in the design processes of the two cases. Even though predicted insights are expected, new insights are also expected to be discovered from the case data. In the theory building process, new insights confirming a causal relationship increase research validity, which should not be treated as either contrasting or spurious factors to disconfirm the theoretical proposition (Eisenhardt, 1989). This means that the new insights – if they emerge in both cases and are characterised by recurrence amongst the two cases – could contribute to yielding richer insights for improving the original theoretical proposition, further strengthening the cause-effect relationships. Identification of important insights strengthens the likelihood of inferring similar causal-effect relationships in other cases. Finally, analysing the two cases determines that the theoretical proposition is applicable to both cases to enhance design for sustainability.

Having explained the fundamental logic of case study for case comparability, the technical step of how to analyse their results is presented next. The strategy adopted is the theoretical proposition strategy (Yin, 2014 [1984]), which means that the theoretical proposition is used as a dimension for seeking predicted insights, leading to the outcome of creating strategic design solutions for short-term planning. The theoretical proposition comprises five design implications developed from their theoretical insights. The five implications have clearly defined each of their unique roles in leading to each intended outcome, and as a whole the five roles would develop strategic design for short-term future planning to mitigate reverse salients. All roles are expected to be identified in this case analysis to show how they contribute to the case results. The five design implications suggest the five roles of:

- analysing transitions from a multilevel perspective
- identifying reverse salients
- correcting reverse salients
- setting guidelines for actions
- justifying the working solutions

To operationalise the strategy, an analytic technique is applied. The technique is partly a concept of pattern making wherein the matching is based on how the case data fit the five design implications. In this way, the matching or mismatching result will either confirm or disconfirm the original proposition (Yin, 2014 [1984]). Yet the analytic process is not conducted in an utterly mechanical fashion. Rather, the comparison is done in a more narrative style, through tracing the design processes of the two cases. This is another technique adapted from building case explanation (Yin, 2014 [1984]). Explanation through a tracing process investigates how the theoretical insights are adopted throughout the design process. When design is linked to the broad and highly complex systems landscape, it is essential to scrutinise the subtle similarities and deeper links underlying the five insights. If the subtlety and underlying links deepen the predicted insights or reflect new insights causing the case results, these would yield substantially rich insights into improving the theoretical proposition.

At the end, if the two case analyses confirm that all roles contribute to enhancing design to succeed in developing short-term future planning to mitigate reverse salients, it would be possible to reflect a recursive result in other transitions cases in similar settings by applying the theoretical proposition. After clarifying the analytic approach to analysing the two cases, the next section explains the analytic process.

5.1.2 Analysing the two cases

The analytic process began from identifying the five design implications of the theoretical proposition in both case studies. They are the predicted insights that have led to the outcomes of creating strategic design solutions for short-term future planning in each case. This analysis confirms whether or not the presumed causal relationship is found in the individual cases. Besides the predicted insights, new insights that may contribute to a successful outcome in creating strategic design solutions for short-term future planning may also be discovered. In the theory-building process – that is, theoretical proposition development and improvement in this research – emergent insights provide opportunities to improve the original proposition (Eisenhardt, 1989). Given this, empirical research reveals new layers of relationships regarding how the theoretical insights cause the case result, thereby yielding deeper insights into the relationships. In this research, if the new insights are identified in both cases, they indeed further strengthen the causal relationship between the theoretical proposition and case outcomes. Towards the end of the analytic process, when most of the theoretical insights have been identified from empirical data and there are no further new findings, this indicates that the iteration between theoretical proposition and case data has almost come to the end.

The following is a discussion of the two-case analysis, with a focus on searching for design implications in the individual two cases. A table that organises the analysis results is presented below (Table 7, Identifying the predicted insights and new insights from the two case results). The juxtaposition of the two case results is organised in four columns. The first column on the left specifies the predicted insights, that is, the design implications emerging from the theoretical insights. The middle two columns describe the causes and causal links drawn from the two case study results (Case study 1 and Case study 2) in detail. The last column on the right of the table shows new insights that emerged during the design processes in the two case studies. The new insights are not expected insights but they may yield richer insights into improving the original theoretical proposition.

Table 7. Identifying predicted insights: the predicted insights and new insights identified in the two case results.

Predicted insights	**Case study 1:** Renewable energy transitions applied to advancing solar photovoltaics in the built heritage of Dipoli	**Case study 2:** Sustainable aquaculture transitions applied to Finnish salmon trout aquaculture in the Baltic Sea	**New insights**
▪ **Analysing transitions from a multilevel perspective**	Identified. MLP is adopted to complete transitions analysis. Transitions projections, niche pathways and alignment of processes amongst the heritage constituency, Aalto University Properties and Aalto University Presidency are analysed to avoid returning to fossil fuel regime.	Identified. MLP is adopted to complete transitions analysis. Transitions projections, niche pathways and alignment of processes amongst the measures of the Ministry of Agriculture and Forestry, fish farm licensing, fish farmers' responsibility and fish consumers' interest in consuming locally farmed fish are analysed to avoid strengthening the dominating imported salmon regime.	Case study 1: VSD for value investigations reveals and prioritises three conflicting values. Case study 2: interlevel transitions pathways for analysis as well as its concept of transferability are used to develop design solutions.
▪ **Identifying reverse salients**	Identified. Reverse salients that are likely forming are reflected in the architectural experts' opinions about the renovation plans of Dipoli. The analysis of reverse salients implied that it is critical to implement the solution before other less desirable	Identified. Reverse salients that are likely forming are reflected in the issues of fish farmers' prospect of attaining ASC accreditation and the stringent fish farm licensing of AVI. The analysis of reverse salients implied that it is critical to implement the solution before	Both cases follow the same sequence of, first, "analysing transitions from a multilevel perspective" and, afterwards, "identifying reverse salients." However, both cases also show a constant iterative analysis

	Dipoli renovation measures are implemented by 2015-16.	the announcement of the results of ASC accreditation for both Finnish farmed salmon trout and Norwegian farmed salmon.	backwards and forwards between the said two roles. Case study 1: architectural review is conducted. Both cases inform the timing for a short-term future projection in the short term.
▪ **Correcting reverse salients**	Identified. Reverse salients of aesthetic and heritage values held by those who find the idea of solar PV installation unacceptable are defined as critical problems for correction. The solution goal is to demonstrate to Aalto University Properties a practical solution that is a working compromise between the conflicting values of preservation, modernisation and aesthetic values.	Identified. Reverse salients of high investment costs of offshore aquaculture were defined as critical problems for correction. The solution goal is to provide fish farmers a viable means of investing in sustainable salmon trout aquaculture in the Baltic Sea and maintaining the marine ecosystem of the sea in the long term.	While defining the need for a solution, both cases return to the earlier roles of "analysing transitions from a multilevel perspective" and "identifying reverse salients." In both cases, the solutions are visualised and presented in visual forms.
▪ **Setting guidelines for actions**	Identified. Guidelines to guide Aalto University Properties how to site PV in Dipoli and furthermore other similar sustainable renewable energy investigations in Finland. The actions have to align with the longer-term goals of renovating heritage buildings by 2015 as well as realising the vision of an energy self-sufficient campus by 2030.	Identified. Guidelines guide fish farmers to invest in offshore fish farms in the Baltic Sea and adopt the recirculation of nutrients concept, as well as guide fish consumers to make sustainable fish choices. The actions have to align with the longer-term goals of increasing national farmed fish production by 2020 as well as the mid-term EU vision of the Blue Growth strategy.	The guidelines set in both cases are based on the defined goals of solutions from the previous role of "correcting reverse salients." The guidelines are clearly and strictly set in visual forms in both cases. This role is closely connected to the following role and they are taken together.

	The guidelines are visualised in a set of architectural renderings.	The guidelines are visualised by a tangible fish certification.	
▪ **Demonstrating the feasibility of the solutions**	Identified. The feasibility is demonstrated by the arrangement of solar PV panels in the architectural renderings.	Identified. The feasibility is demonstrated by the three eco-rating principles behind the classifications of eco-ratings.	The rationales shown behind solutions in both cases are based on the solution goals that are defined earlier. Both cases conducted technical and/or document analysis to attain evidences to help prove feasibility. The rationales behind the solution are shown in tangible means. This role is closely connected to the previous role and they are taken together.

Analysing transitions from a multilevel perspective

In case study 1, solar PV in the Dipoli case, the design process begins with conducting a conceptual analysis of the transitions situation through the MLP analytical framework to attain a multilevel systems perspective. While adopting MLP, both societal and technological elements are mapped on the configuration for analysis. In this case, the foreseeable result of Dipoli's renovation was either heritage preservation without installing any solar PV panels or a loss of aesthetic quality and heritage value due to a lack of competence in installing solar technology in built heritage. From a systems perspective, either foreseeable result would have easily set back renewable energy development, forcing a return to the fossil fuel regime. In addition, adopting the framework of Value Sensitive Design (VSD) to investigate conflicting values amongst stakeholders further reveals the uneven quality of niches growth in this transitions situation. The identified key stakeholders are the heritage constituency, heritage property owner (Aalto University Properties) and Aalto University Presidency, which could hold back renewable energy transitions. The problems expressed in the architectural experts' opinions that the heritage rooftop is inaccessible and inappropriate for siting solar PV indicate the critical phenomenon of the categorical rejection of solar PV installation. Yet using MLP to analyse the alignment of the values and activities of key stakeholders tends to reveal an opportunity for niches to break through into the regime. The case shows that attaining a multilevel perspective from MLP has provided a systems understanding of the transitions dynamics of the situation and analysed transitions projections for niche pathways. Additionally, informed by the three prioritised values investigated from VSD and transitions analysis, an architectural review is conducted to understand the heritage value of Dipoli.

In case study 2, the salmon trout aquaculture case, the design process also begins from conceptual analysis of the transitions situation by adopting MLP to develop a systems perspective. The configuration mapped all systems elements relevant to the transitions situation, including both societal and technological elements for analysis. In this case, the foreseeable result of the Finnish sustainable salmon trout transitions was either an increase in salmon trout production in the Baltic Sea that would logically accelerate marine eutrophication, or a total lack of offshore salmon trout aquaculture that would result in favouring and strengthening the dominance of imported Norwegian farmed salmon in the Finnish fish market. Adopting a systems perspective, either of these foreseeable results would put further curbs on the already restrained market for Finnish sustainably farmed salmon trout. The problems inherent in assuming that Finnish salmon trout aquaculture in the Baltic Sea will be ASC accredited indicates the critical phenomenon that fish farmers are not investing at all in offshore sustainable salmon trout aquaculture. Yet, analysing the transitions situation from MLP has also informed the identification of a tactical engagement site for key stakeholders to facilitate transitions when the values and activities of key stakeholders are aligned. In this case, these are the measures of the Ministry of Agriculture and Forestry, fish farm licensing, fish farmers' motivation and responsibility to sustainably expand fish farming and fish consumers' interest in consuming locally farmed fish. The case shows that MLP has provided a systems understanding of the transitions dynamics of the situation and analysed transitions projections for niche pathways. In addition to using MLP multilevel transitions analysis for transitions patterns, the case also adopts interlevel transitions pathways, that is, niche-regime translations and also the concept of transferability to leverage niche-regime dynamics as a source of change.

Identifying reverse salients

After conducting transitions analysis of MLP and VSD, design has been directed to issues of reverse salients. At this stage, field work is carried out in both cases. In case study 1, solar PV in Dipoli, field work is done by applying various research methods including field observation, on-site prototyping, interviews with key stakeholders, document analysis and technical analysis. The field work scrutinises the transitions situations regarding reverse salients in a real-life context. Field work deepens the understanding of the heritage architectural value. In addition, during empirical observation, reverse salients that are likely forming are reflected in the expert opinion held by the architectural professor, who assumed that the rooftop is inaccessible, and the aspiration of the conservation architect to restore the roof to its original state – they seemingly would have categorically forbidden the installation of any solar PV panels on Dipoli, setting up a likely reverse salient. These issues are the problems inherent in reverse salients and they constituted major reverse salients hampering overall renewable energy transitions growth. The analysis of reverse salients in the solar PV in the Dipoli case implied that it was critical to come up with a solution before the experts' recommendations regarding the Dipoli renovation plans and other less desirable renovation measures were implemented by 2015-16.

In the salmon trout aquaculture case, field work is carried out to grasp contextual understanding in order to analyse issues of reverse salients. The adopted case study methods include field observation, interviews with key stakeholders, literature search and document analysis. In this case, the reverse salients that are likely forming are reflected in fish farmers' prospects of attaining ASC accreditation. This is a reverse salient. In addition, the stringent fish farm licensing of AVI also constitutes a reverse salient. This is reflected in the factual data that only one licence was approved by AVI in the past year, which has intimidated fish farmers from exploring offshore aquaculture. These indicated the reverse salients of the high investment costs of offshore aquaculture and the uncertain fish feed costs, together with the ensuing quality of the farmed salmon trout. Fish farmers anticipate that securing accreditation for Finnish farmed salmon trout would correct the reverse salients – that is, the high investment costs. However, attaining ASC accreditation is unlikely to be achieved, which would cause a loss of momentum among fish farmers in their efforts to grow sustainable salmon trout aquaculture. These two critical issues are likely to set up reverse salients in the near future, which would prevent the Finnish sustainably farmed fish production target from being achieved. These issues are the problems inherent in reverse salients and they constituted major reverse salients hampering overall growth in sustainable aquaculture transitions. Moreover, the time for creating the solution should be before the announcement of the results of the ASC application for Finnish farmed salmon trout, probably within one to two years, and the realisation of ASC accreditation of Norwegian farmed salmon in 2020. Otherwise, the announcement of the results would lead to a loss of momentum among Finnish fish farmers to grow sustainable aquaculture.

By using this insight, both cases follow the same sequence: beginning from the first role of "analysing transitions from a multilevel perspective," followed by the insight of "identifying reverse salients." While beyond a linear sequence, the two cases also show a constant iteration analysing backward and forward between the said two insights. These two roles are found to be closely connected in order to analyse their specific transitions situations, which marks a newly found insight. In addition, the analysis of reverse salients in both cases indicates that the short-term future projection must be timed to occur before other undesirable renovation measures are taken, which would result in failure to achieve the respective sustainability targets in both cases. The insight adopted in both cases succeeds in analysing issues of reverse salients, and the goals for solutions are defined on the basis of these issues. These directed design to seize opportunities for a design intervention in transitions.

Correcting reverse salients

In case study 1, the reverse salients of aesthetic and heritage values held by those who find the idea of solar PV installation unacceptable defined as critical problems for correction. To correct them, the solution has to show to Aalto University Properties that the architects' recommendations should not be considered to be the optimal way to renovate Dipoli. Instead, the goal is to demonstrate an alternative solution that is a working compromise between preservation, modernisation and aesthetic values. At this time, the design process returns to transitions analysis for analysing transitions projections amongst the interferences of activities for an alignment of the different values and activities of stakeholders and a tactical engagement site that is favourable for a niche breakthrough.

In case study 2, the reverse salients of high investment costs of offshore aquaculture are defined as critical problems for correction. In this salmon trout aquaculture case, the solution needs to demonstrate to fish farmers a viable means of investing in sustainable salmon trout aquaculture in the Baltic Sea and maintaining the marine ecosystem of the sea in the long term. In the process, the case also returns to transitions analysis to further analyse the transitions pathways, including multi-level and inter-level interactions, projections and niche pathways for a tactical engagement site of common interest to the key stakeholders in order to facilitate transitions. Based on transitions pathways, the case also adopts the concept of transferability to develop alternative solutions for a niche breakthrough.

Both cases articulate the goals for solutions by defining reverse salients as critical problems for correction plans to practically solve the identified problems inherent in their reverse salients. Both cases return to the earlier role of "analysing transitions from a multilevel perspective" to analyse the alignment of values and activities of stakeholders in systems for a tactical engagement site for a niche breakthrough. Also, in both cases, a design intervention has to be initiated early and operationalised before other less desirable measures impede transitions; furthermore, it was concluded that short-term planning is required.

Moreover, in both cases, the solutions are presented in neither written nor verbal form. Rather, the short-term future planning is visualised and presented in visual form. In case study 1, a strategic design visualisation of an architectural rendering is created; the rendering visualises the optimal way of installing solar PV in Dipoli in detail and high precision. In case study 2, strategic design certification in the visual form of a certificate is also created; this certificate visualises the eco-rating information in high clarity and definition. The two solutions in their visual formats simultaneously bring forward issues of reverse salients to the forefront of transitions and, furthermore, offer alternatives to mitigate reverse salients. In case study 1, the architectural rendering, on the one hand, suggests that the experts' recommendations are not the only viable approaches to the renovation plans of Dipoli, and on the other hand presents an alternative solution for siting solar PV in built heritage. In case study 2, the sustainable farmed fish certificate, namely the Finnish Ekofish Certification, on the one hand brings forward the problems inherent in the issues of the ASC certification to the forefront of Finnish sustainable salmon trout aquaculture transitions. On the other hand, it visualises the potential prospect of developing sustainable aquaculture to fish farmers. Moreover, the solutions are tangibly visualised in high quality in both cases. Attaining this quality of visualisation makes the future more visible and comprehensible to be seen, noticed and experienced by Aalto University in case study 1, and the fish farmers, consumers and the Finnish Ministry of Agriculture and Forestry in case study 2.

Setting guidelines for actions

In case study 1, the solution requires setting guidelines for Aalto University Properties to instruct how to arrange solar PV panels on Dipoli in a culturally sensible way in terms of practicality and aesthetic quality suited to a cultural heritage building as well as an optimal means of achieving a compromise between conflicting values. In addition to guiding how to site solar PV panels on Dipoli, the guidelines also serve as a demonstration for other heritage buildings across campus and other similar sustainable renewable energy investigations in Finland. When setting the guidelines, the expected actions that are to be taken at present align with the longer-term goals of renovating the heritage building by 2015 as well as realising the vision of an energy self-sufficient campus by 2030. To achieve the intended guiding outcomes, the guidelines are set in the format of a strategic design visualisation (architectural rendering) and in a specific quality of visualisation. The solution is enhanced by the quality of concreteness, high resolution, clarity, tangibility and realness. The architectural rendering concretely defines the concept of subtle visibility from various angles, particularly the precise view from 100 metres away from Dipoli at ground level, to support the working compromise. It is in high-resolution and contains a large quantity of detailed information in terms of quality of solar PV panels, their positions, tilt angles, directions, and arrangement and so on. The visualisation is also rendered in high clarity to make it easier for stakeholders to understand the issues. Setting the guidelines in a tangible format enhances engagement with stakeholders to spark more discussions on the solutions, thereby enabling them to deliberate on their own plans to facilitate transitions. The rendering is also projected based on the real context of Dipoli with a view to making it easier for stakeholders to see future circumstances.

In case study 2, the salmon trout aquaculture case, the solution needed to set guidelines to encourage fish farmers to practise sustainable aquaculture by siting sustainable salmon trout aquaculture offshore in the Baltic Sea and adopting the recirculation of nutrients concept. The fish farmers' actions are to be taken at present, but they also have to be aligned with the sustainable measures of the Ministry in order to produce a transition. Additionally, the guidelines also guide fish consumers to make sustainable fish choices, particular to favour the consumption of local sustainably farmed salmon trout. When setting the guidelines, the expected actions that must be taken at present align with the longer-term goals of increasing national farmed fish production by 2020 as well as the mid-term EU vision of the Blue Growth strategy. These guidelines are visualised by the classification of eco-ratings in a tangible fish certification. To achieve the intended guiding actions, the guidelines are set by three eco-ratings and visualised in the tangible format of strategic design fish certification. The viable means is visualised to fish farmers to demonstrate that it is feasible to invest in sustainable aquaculture in the offshore Baltic Sea while at the same time minimising nutrient loading to the sea. The certification also visualised to fish consumers that sustainably farmed local fish is available and indicated how sustainable these fish are, thereby informing their sustainable choices in consuming fish. The concept of the certification is enhanced by the quality of visualisation thanks to its concreteness, high resolution, clarity, tangibility and realness. The certification is concrete, precisely defined by design elements comprising the certification logo, classifications of eco-ratings and the set of criteria for assessment, which give assurance on the feasibility of the certification scheme. The certification is also visualised in high resolution and clarity containing the necessary information and details to enable the solution to be understood. It is launched in a tangible form of a certificate that is not an abstract concept. Physical interaction with stakeholders would engage actions from fish farmers and fish consumers, and additionally induce practical discussions amongst the Ministry of Agriculture and Forestry and AVI about developing relevant measures reflected by the design solution. The certification also connects to the realistic context of the existing fish market, which enables fish farmers to foresee future issues when the effects of reverse salients are not as yet present.

Both cases set guidelines based on the defined goals of solutions that have been guided by the previous insight of "correcting reverse salients." The guidelines are presented in visual form in both cases, namely, the strategic design architectural rendering and fish certification. The clear and strict guidelines aid in the operationalisation of the solution by setting guidelines to steer actions to mitigate]reverse salients.

Demonstrating the feasibility of the solutions

In case study 1, the feasibility of the alternative solution is shown by the optimal arrangement of solar PV on the rooftop of Dipoli, compromising the values of preservation, modernisation and aesthetic quality of siting solar PV in built heritage. The evidential proof includes the quantity, arrangement, positions, tilt angles and directions that provided the rationales behind the solution. Moreover, the feasibility of the solution is additionally justified by the relevant technical and costs data to support its technical and economic viability. This shows how solar PV should be arranged on the rooftop when these considerations are taken into account. The rationales behind the solution of the strategic design visualisation are provided in tangible means by the arrangement of solar PV behind the architectural rendering. They are supported by sufficient technical analysis including an electricity consumption report and solar irradiance simulation map in order to clarify the technical and economic viability of the solution.

In case study 2, the feasibility of the alternative solution is demonstrated by the three eco-rating principles, in which the highest eco-rating prioritises ecological health. The highest eco-rating requires fish farmers to site fish farms offshore in the Baltic Sea and adopt local fish feed. The justification of the eco-rating principles provides reasons to fish farmers to invest in sustainable aquaculture that could be in line with the sustainability measures of the Ministry of Agriculture and Forestry as well as the legislation on fish farm licencing. The solution has indeed provided a viable means for fish farmers to viably invest to facilitate transitions, which fulfils the needs to solve the identified problems inherent in reverse salients. To justify the viability of investing in offshore aquaculture, the justification is supported by document analysis of existing aquaculture measures and policies. The rationales behind the solution are shown by the classifications of eco-ratings and the certification is delivered in physical form as a certificate that enhances the visibility of new directions to fish farmers and fish consumers. The alternative viable solution makes it easier for them to prepare their own plans to invest in offshore salmon trout aquaculture. The rationales behind the solution of the strategic design of fish certification are supported by obtaining evidence through document analysis.

Both cases demonstrate the feasibility of solutions based on the defined goals of solutions that have been guided by the previous insight of "correcting reverse salients." The rationales behind the solutions are provided in tangible means in both cases, that is, the arrangement of solar PV behind the architectural rendering and eco-rating principles behind the fish certification solution. The insight succeeds in directing design to prove the feasibility of the alternative solutions with a tangible approach. It aids in the operationalisation of the solution to prompt stakeholders into actions. The practical feasibility of the solutions is proved through a tangible approach in both cases.

5.2 The predicted insights and new insights

The dynamics between the theoretical insights and empirical evidence in each case have been discussed in detail in the analytic process. From the discussion, a pattern of causal relationships between the predicted theoretical insights and empirical evidence is identified. At the same time, new insights also emerged from the two cases, contributing to new roles in the design process. The discussion below elaborates the confirmed insights and new insights identified from the case analysis to deepen how the proposition has enhanced design for sustainability in the two cases.

Confirming the five predicted insights

As expected, all predicted insights are identified in the design processes of both cases. This means that the five theoretical insights are all adopted in both case studies and each of the five theoretical insights has played its unique role though exercising each of the specified activities to create short-term future planning to mitigate reverse salients.

A flexible design process model

An additional analytic tool, the VSD framework, is adopted in case study 1. The VSD framework aids transitions analysis to discover values that need to be taken into consideration when designing technology. In particular, when cases are value-sensitive, such as in this energy transitions case involving multiple conflicts between the values of heritage, users and aesthetic as well as energy efficiency, VSD contributes to investigating and prioritising key stakeholder values to arrive at a working compromise. In the case, VSD has discovered values that are sensitive to human values concerning environmental sustainability. To facilitate transitions analysis, the investigated values are charted on MLP to analyse niche pathways, which furthermore enhances transitions analysis to reveal uneven niche growth in systems. VSD certainly contributes to the design process to aid transitions analysis in this case. Observation of the design process of case study 1 also indicates that the flexibility of the design process model in accommodating other analytic frameworks, methods and tools to aid transitions analysis also contributes to success. In this way, other frameworks, methods and tools, such as VSD, should be explored for adapting to the design process as useful tools to aid transitions analysis.

A consecutive sequence

Both cases apparently imply a consecutive sequence from the first theoretical insight to the last. It is also discovered that some insights strictly guide the others in the design process in an integrative manner. The first two roles of analysing the transitions situation and anticipating reverse salients are synthesised for the third role of correcting reverse salients to initiate alternative solutions. Afterwards, the alternative solutions completed by this third role of correcting reverse salients function as a blueprint to direct the two succeeding roles of setting guidelines and justifying the working solutions. The guidelines and feasibility of the solutions in both cases are set and proved in accordance with the solution goals, timing and space that are determined by the role of correcting reverse salients. This expresses the directing role of correcting reverse salients, which is pivotal to steering the development of short-term future planning. While developing the planning, the roles of setting guidelines and demonstrating the feasibility of the solutions are also synthesised for alternative solutions. The functioning of the roles indicates a consecutive sequence and each role guides each other in an integrative manner.

The consecutive sequence also displays an integrated design process model. Fundamentally, the initial proposition consists of theoretical insights drawn from transitions studies and strategic design studies, respectively. This naturally presents a design process structure that tends to comprise two phases: the analytic phase and operational phase. One phase is analytic due to the analytic nature of the three insights drawn from transitions studies that contribute to analysing reverse salients. Another phase is operational due to the more actionable nature of the latter two insights contributing to operationalising solutions to mitigate reverse salients.

However, as discussed above, the empirical research discovers many more cycles of iterations amongst the roles taken in creating design solutions throughout the design process in the two cases. In case study 1, playing the roles of analysing the transitions situation and major reverse salients developed the concept for the necessary solution in terms of a design visualisation in an early phase of the process. Only a design visualisation (as an architectural rendering) could detail the solar PV arrangement, quantity, positions, tilt angles, directions and so on in order to guide Aalto University how to install solar PV, for it lacked the competence to carry out a culturally sensible design. The need for an architectural rendering has also reversely influenced the analysis of transitions to particularly analyse issues of heritage regarding the original design concept of the architecture, its heritage values and aesthetic quality. In case study 2, analysing the sustainable aquaculture transitions situation already revealed the need to project a viable sustainable salmon trout market for fish farmers. Only a design certificate visualisation could concretely bring forward many reverse salients issues to present a stakeholder tactical engagement site and, in addition, to correct the aspirations of the fish farmers to secure ASC accreditation. The need for design visualisation (the resulting strategic certification), in turn, has influenced transitions analysis to particularly analyse the alignment of the measures of the Ministry of Agriculture and Forestry with the interests of the niche, regime and consumers (that is, the transitions interlevel) in the sustainable aquaculture systems. The two case studies express a dynamic relationship amongst transitions insights and strategic design insights, which forms an integrated design process.

Still, based on two case studies, it would be too early to conclude whether the design process is a completely integrated model that combines the two sets of insights or an integrated model additionally underpinned by a two-phase structure. The confirmation requires more cases to observe how the two sets of insights mutually influence and support each other. At this stage, this analysis proposes an integrated design process model but also expects to further explain the structural aspect of the model with more future research.

An iterative approach

Both cases indicate that some roles are closely connected and taken in an iterative manner. As investigated in the case studies, the first two roles of analysing the transitions situation and anticipating reverse salients are examined backwards and forwards iteratively. This is due to the fact that the conceptual understanding of transitions analysis provides explanations for the empirical insights emerging in the exploration of contemporaneous issues of reverse salients in a real context. In turn, empirical evidences simultaneously enhance transitions projections in the analysis. Similarly, another two roles of setting guidelines and demonstrating the feasibility of the solutions are also observed to be closely taken in iterations. This is accounted for when guiding the actions; the feasibility of the solutions has to be demonstrated, as otherwise the guidelines cannot be clarified to engage key stakeholders to facilitate their own plans based on the guidelines. It is observed that some roles return to earlier activities to obtain more information and indications. When playing the third role of correcting reverse salients to initiate alternative solutions, both cases return to the earlier analysis roles in the design process. They return to the roles of analysing transitions to examine the alignment of the values and activities of stakeholders in systems to seek a stakeholder tactical engagement site and anticipate reverse salients to review the goals and timing of the solutions. When taking the role of setting guidelines for actions, the two cases return to the earlier roles to review the solution goals as well as transitions analysis in order to develop guidelines for actions at present aligning with their longer-term sustainability targets. The above empirical observation explains that the design process proceeds in an iterative manner where the roles are analysed and reviewed backwards and forwards iteratively amongst them.

This insight (an iterative approach) and the previous one (a consecutive sequence) regarding the sequential aspect indicate an integrative and iterative design process wherein each insight plays its unique roles in a coherent way. Empirical research reflects many more cycles of iterations that occurred throughout the design process; they exhaust the theoretical insights to provide sufficient and in-depth details and full information to enhance the design process. This indicates a strong causal relationship amongst the theoretical insights and case data.

A new visualising role

As discussed previously, all five roles of the initial proposition are confirmed in both case studies, as they all contribute to developing short-term future planning that targets reverse salients. Hence, they are all retained in this proposition development. Along with the five confirmed roles, a new role emerged in the design process: a visualising role. This role visualises the alternative solutions. Precisely, visualising solutions should not be a new role, but one which has been confirmed under the roles of setting guidelines for actions and demonstrating the feasibility of the solutions. However, the role of visualising the short-term future planning has a key significance that should be discussed as a separate role in the design process. The reasons why this role is suggested to be formulated as a distinct stage are explained below.

As suggested in the initial design process, both the roles of setting guidelines for actions and demonstrating the feasibility of the solutions have to respectively visualise the guidelines and rationales behind the solutions in visual, tangible forms.

Taking these two roles, the guidelines and rationales are presented in a visual form of short-term future planning. In case study 1, a strategic design visualisation in the visual form of an architectural rendering is developed to demonstrate an alternative way of installing solar PV panels on Dipoli against the architectural experts' recommendations. In case study 2, a strategic design certification in the visual form of an Ekofish certificate is also created to visualise an alternative prospect for developing sustainable aquaculture for fish farmers instead of desiring in vain for ASC certification. The visualisation of the architectural rendering incorporates the concrete solar PV arrangement that guides Aalto University to site solar PV in built heritage in a culturally sensible way. Also, the visualisation of the Ekofish certificate precisely defined the eco-rating classification that guides fish farmers to invest in offshore aquaculture. These solutions visualised in specific quality are developed to guide stakeholders to take the intended actions. Moreover, the visualised solutions give assurance on the feasibility of the solutions in order to enable stakeholders to deliberate on their own plans to facilitate transitions. In case study 1, the rationales behind the solar PV arrangement are proved with corroborating technical evidence to clarify technical and economic viability in the consideration of heritage preservation and aesthetic quality. This justifies ecological modernisation. In case study 2, the rationales behind the Ekofish certificate are also expressed by classifying the eco-ratings with principles that are in line with the measures of the Ministry of Agriculture and Forestry as well as the consumer market for sustainable fish. This justifies a solution that is economically viable and also improves the marine ecosystem. Visualising clear, concrete guidelines and rationales in a tangible form has fulfilled the roles of setting guidelines and demonstrating feasibility, but visualising indeed has a more pivotal function as observed from the two cases.

In both cases, design visualisation has brought forward issues of reverse salients to the forefront of transitions (issues concerning the architectural experts' recommendations in case study 1 and ASC certification in case study 2) and furthermore offered alternatives to stakeholders to realise other possibilities for achieving their sustainability targets (ecological modernisation solutions in case study 1 and simultaneous economic viability and marine ecosystem improvement in case study 2). Visualising the short-term future planning has a significant role in characterising strategic design for the short-term future. Taking a strategic approach to the short term entails developing design solutions whose present operational effectiveness fulfils short-term future goals in order to achieve longer-term visions. To this end, visualising short-term future planning is important in the design process for playing a pivotal role. In view of its importance with regard to improving the initial proposition, it is suggested that a stage of visualising short-term future planning be added after the stage of initiating alternative solutions. Although this stage is referred to as "visualising short-term future planning," it does not merely include visualising alternative solutions, as the role also contains forward-thinking planning for the near future. The new role involves bringing forward issues of reverse salients to the forefront of transitions and also incorporates the roles of setting guidelines and demonstrating feasibility. The roles of setting guidelines and demonstrating feasibility remain separate stages because of their particular scopes and activities involved in fulfilling their roles. However, it is also assumed that the three roles of visualising short-term future planning, setting guidelines for actions and demonstrating the feasibility of the solutions are closely connected and taken in an integrative manner.

Concretising the concept of the short-term future

The conceptual time frame of the short-term future is concretised further. Empirical observation of the two cases suggests that the time frame of short-term future planning can be informed by diagnosis of reverse salients. Yet, at the same time, there is a limited window of time during which reverse salients can be targeted before they hamper new systems growth. In both cases, short-term planning is created for a period covering one to two years. This additionally gives substantial evidence to the theoretical proposition to identify opportunities for design interventions within the near future on a time frame of one to two years. Six confirmed insights and new insights are presented below (Table 8).

Table 8. The predicted theoretical insights and new insights captured from empirical observation.

The predicted and new insights	Descriptions		
Predicted insights confirming the theoretical proposition	1.	Confirming the five predicted insights	▪ all five of the predicted insights are confirmed to be adopted in both cases and they all contribute to the design process
	2.	Concretising the concept of the short-term future	▪ the time frame of short-term future planning within which reverse salients can be diagnosed, which is approximately one to two years
New insights contributing to new roles in the design process of the theoretical proposition	3.	A flexible design process model	▪ a flexible design process model accommodating other analytic frameworks, methods and tools to aid transitions analysis
	4.	A consecutive sequence	▪ the functioning of the roles indicates a consecutive sequence in an integrative manner with each role guiding each other
	5.	An iterative approach	▪ the design process proceeds in an iterative manner where the roles are analysed and reviewed backwards and forwards iteratively
	6.	A new visualising role	▪ a pivotal role to visualise strategic design solutions that have operational effectiveness to fulfil short-term future goals

5.3 Chapter summary

This chapter analyses the application of the initial theoretical proposition to two case studies and identifies causal relationships in the two individual cases. The two cases are the case of renewable energy transitions applied to advancing solar photovoltaic in built heritage (solar PV in the Dipoli case) and the sustainable aquaculture transitions applied to Finnish sustainable salmon trout aquaculture in the Baltic Sea (salmon trout aquaculture case). The two case analysis results confirm that the theoretical proposition is applicable to sufficiently explain both cases in creating short-term future planning that targets reverse salients.

The first section (Section 5.1) clarifies the analytic approach to analysing the two cases. This includes the case study strategy, theoretical proposition strategy, pattern making and building explanation that are applied to achieve research validity. The latter part of the section analyses the two cases by comparing the roles of each theoretical insight taken in the design process against empirical evidence in each case. The analysis confirms the predicted theoretical insights of the initial proposition as well as discovers new insights that are captured from empirical observation in both cases.

The second section (Section 5.2) elaborates in detail the predicted and new insights that have enhanced the design process in the two cases. The identification of all the predicted insights taken in both cases confirm the applicability of the initial proposition to enhance the design process. At the same time, analysis discovers new insights that contribute to the outcome of succeeding in creating strategic design solutions for short-term future planning. The four new insights – a flexible design process model, a consecutive sequence, an alternative approach and a new visualising role – enrich and improve the initial proposition to further strengthen the theoretical proposition. The systematic procedure of case analysis would support the development and improvement of the initial proposition into a genuine design process for design practice to facilitate transitions for sustainability. The next chapter discusses the development of the proposition.

6. Strategic Design for the Short-term Future

To fulfil the research aim of learning to anticipate and overcome obstacles to sustainability transitions in the short-term future, this chapter develops a new strategic design approach. The resulting design approach is explained in a strategic design model that has a solid theoretical underpinning from two fields of study – transitions theories from transitions literature and strategic design from design management literature. The theoretical insights gained from these two fields constitute two core parts of the design model, which initially forms a theoretical proposition (the insights are drawn in Chapter 2). The design model is also empirically valid, which is supported with empirical evidence through investigating the initial theoretical proposition with two case studies (Chapter 4). In case studies, six confirmed insights and new insights are captured from empirical observation to further enrich the theoretical insights for developing and improving the proposition (Chapter 5).

The resulting design approach is practice-relevant for guiding design in the real world for sustainability. To adequately guide new design practice, a theoretical proposition should be developed for formulating principles and organising the design process (Friedman, 2003). This concept of design research connects design practice and academic research based on rigorous insights and systemic inquiry to practically solve problems in the real world (Dorst, 2016). In developing the theoretical proposition, new principles of strategic design for sustainability transitions are formulated for explaining the phenomenon of specific transitions situations in their contextual conditions in a real-life context. For guiding this purpose, the principles are elaborated and organised in a design process to demonstrate the process of creating strategic design solutions for short-term future planning in stages.

In this chapter, the first section (Section 6.1) explains the development and improvement of the initial theoretical proposition. The second section (Section 6.2) presents the new design model of Strategic Design for the Short-term Future and delineates the six-stage design process. The last section (Section 6.3) revisits the two case studies by applying the new design model to confirm that the new model is adequate to support strategic design for short-term future planning. The last section is a chapter summary (Section 6.4).

6.1 Development of the theoretical proposition

Six confirmed and new insights have been introduced from analysing the two cases, which aid in the development and improvement of the initial theoretical proposition. Adopting the six insights, the following section discusses the development of the proposition towards formulating a genuine design process for sustainability transitions for design practice.

The title of each stage

To improve the initial theoretical proposition, the titles of some stages are rephrased. In empirical observation where the initial proposition is investigated through the two case studies, it is clear that all five predicted insights are confirmed in both cases. The confirmation indicates that they all contribute to the design process to develop short-term future planning to mitigate reverse salients. In addition to their functions, the titles of some stages could be rephrased to clearly articulate the role of each stage. The stages are rephrased without changing the scopes and activities of the roles, as all roles are identified to be useful in the design process.

The first title change concerns the first role of "analysing transitions from a multilevel perspective." To make this role clearer, it is suggested that this original title be rephrased to "analysing the transitions situation." The reason for this rephrasing is that other tools, such as the VSD framework, are also accommodated in the design process. The additional tool aids transitions analysis and the benefits it contributes to the design process are evidenced by empirical observation. Based on this empirical evidence, the term "multilevel perspective," which has a strong association with the MLP framework, may be too restrictive, limiting transitions analysis to only adopting MLP. Therefore, the title is clarified to cover the adoption of other tools provided that they can also sufficiently explain the specific transitions situation. Another title change is the third role of "correcting reverse salients." In playing the role, alternative solutions in the two cases are initiated to correct the reverse salients that have been identified earlier. This also reflects the integration of transitions and strategic design insights for the simultaneous activities of correcting reverse salients and conception of alternative solutions. Given this empirical finding, rephrasing the title to "initiating alternative solutions" would describe an actionable role associated with solutions and explicitly clarifies the role. The term "alternative solutions" also guides the type of solutions to offer different possibilities that are also available, which may even be radical, to pursue sustainability targets when transitions reach a stalemate. In addition, a new stage is suggested to be added to the design process as previously discussed, namely: visualising the short-term future planning. Last, the remaining three titles are unchanged: analysing the transitions situation, setting guidelines for actions and demonstrating the feasibility of the solutions.

Now the titles of the six stages become: analysing the transition situation, identifying reverse salients, initiating alternative solutions, visualising the short-term future planning, setting guidelines for actions and demonstrating the feasibility of the solutions. The new, distinct titles enhance the guiding purpose of the design process by sharpening the unique role of each of the stages while also expressing the coherence of the stages when the roles are playing in concert. Now the whole process comprising six stages is presented in the table below (Table 9. The title of each stage). The table juxtaposes the new stage titles (in the right column) and initial titles (in the left column) to show the improvement.

Table 9. The title of each stage.

The initial proposition: the five roles of the design process implied by theoretical insights	The improved proposition: the six roles of the design process after being investigated with case studies
▪ Analysing transitions from a multilevel perspective	**1. Analysing the transitions situation**
▪ Identifying reverse salients	**2. Identifying reverse salients**
▪ Correcting reverse salients	**3. Initiating alternative solutions**
	4. Visualising the short-term future planning
▪ Setting guidelines for actions	**5. Setting guidelines for actions**
▪ Demonstrating the feasibility of the solutions	**6. Demonstrating the feasibility of the solutions**

The sequence and structure of the design process

The initial proposition presents five theoretical insights, implying that each plays a unique role in the design process. In addition to the unique and specific roles of each insight, the earlier discussion (Chapter 2, Section 2.3.2) has also suggested connections amongst the five roles wherein a sequential arrangement of the roles emerges and forms into an initial design process. In empirical observation, these suggestions become evident and concrete.

In case studies, there are three new empirical data offering insights into the structure and sequence of the design process. The new insights suggest that the design process proceeds in a consecutive sequence but also works in an integrative and iterative manner. The design process is integrative because each role in the design process guides and connects to each other. The process is also iterative because the data obtained from each role is analysed and reviewed backward and forward in iterations during the process. Moreover, the analysis proposes a design process model of integration even though a two-phase structure underpins the model.

Based on the analysis, the design process suggests a basic series of sequential steps as a guiding structure. Yet, it is also encouraged to apply the design process in a flexible way suited to specific transitions cases on the provision that all roles are taken in order to achieve the development of short-term future planning to mitigate reverse salients. Given this empirical evidence, the initial theoretical proposition is finalised as a design model featuring a consecutive sequence, an integrative and iterative approach as well as an integrated model to guide design practice. Referring to the above table (Table 9.), the initial titles of the stages are shown in a bullet-pointed list, as they are individual theoretical insights (in the left column). The new stage titles are listed in numerical sequence to formulate the insights into a design process (in the right column).

6.2 The Strategic Design for the Short-term Future: the six-stage design process

6.2.1 Introduction of the Strategic Design for the Short-term Future model

The suggestions to develop and improve the initial theoretical proposition have informed a new design model. This section presents the new model that guides design practice for the short-term future for sustainability.

Strategic Design for the Short-term Future is a new design model that serves to guide the design process to create strategic design solutions for short-term future planning targeting to mitigate reverse salients arising in transitions. To achieve its guiding purpose, a design process is formulated in the model with stages of development for strategic design solutions. The design process involving six stages is arranged in a basic sequential process, but the stages can be followed in a flexible way provided that each of the six stages is completed. The model is also framed in an integrative and iterative process. It is integrative because each phase guides and connects to each other; it is iterative because work from each phase is reviewed and analysed backwards and forwards in cycles throughout the design process. The six stages are: analysing the transitions situation, identifying reverse salients, initiating the alternative solutions, visualising the short-term future planning, setting guidelines for actions and demonstrating the feasibility of the solutions. A diagram of the design process of Strategic Design for the Short-term Future is shown below (Figure 26. Strategic Design for the Short-term Future: the six-stage design process).

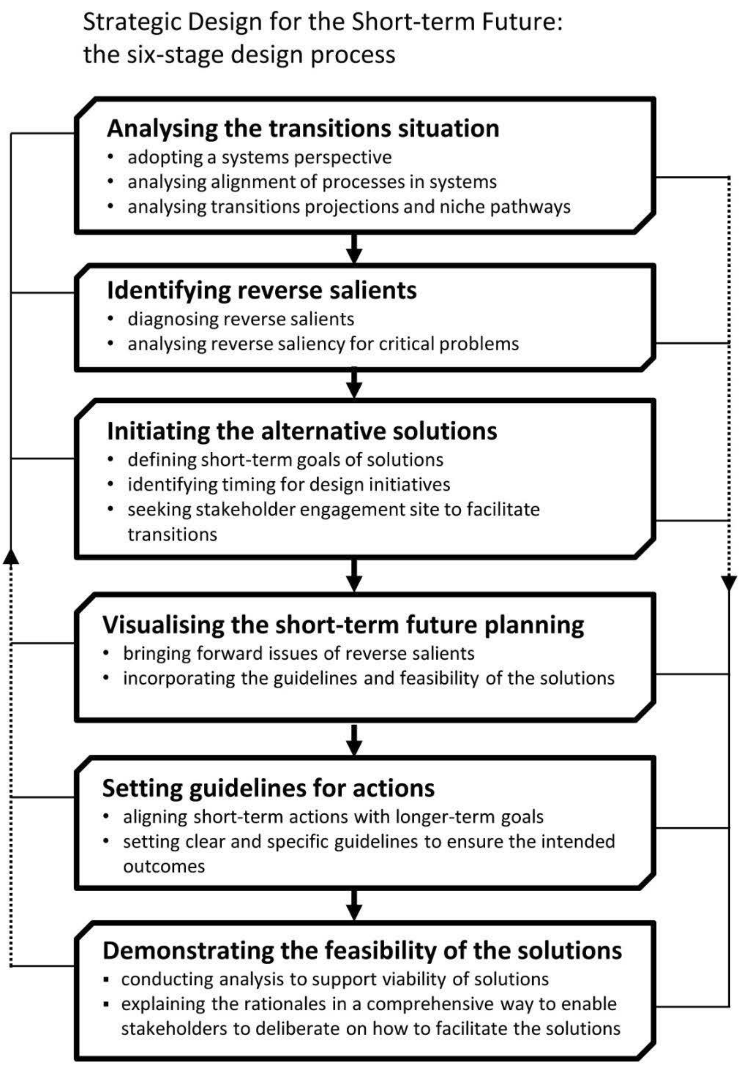

Figure 26. Strategic Design for the Short-term Future: the six-stage design process – an integrated design model for sustainability transitions consisting of a six-stage design process taken in an integrative and iterative manner.

The diagram illustrates the new design process. Basically, a series of six sequential steps taken in an integrative and iterative manner is framed in an integrated design model. In the diagram, the short arrows in solid lines linking the six stages denote the design process in sequential order. The integrative and iterative process is indicated in the dotted-line feedback loop showing the cycles of reviewing, analysing and guiding backwards and forwards throughout the design process. The dotted-line feedback loops are important because the results of some stages in this process may guide the process to return to earlier stages in order to obtain more information or verify the work. Moreover, certain stages may synthesise some closely related issues for other stages.

6.2.2 The six-stage design process of the design model

This section elaborates the six-stage process of creating strategic design solutions for short-term future planning stage by stage. The discussion is structured into a description of each stage and role as well as the activities involved in each stage to fulfil the role.

Analysing the transitions situation

Targeting reverse salients developing in transitions dynamics, the first and foremost step is to analyse the transitions situation. The analysis explains a specific transitions situation that provides background understanding to investigate reverse salients.

The stage of analysing the transitions situation sets the role to analyse to complete a conceptual analysis of a specific transitions situation in its systems. The activities involve (1) adopting a systems perspective. The complexity of interdependencies in systems requires the adoption of a systems perspective in order to comprehensively understand specific transitions situations. The multilevel perspective (MLP) analytical framework from transitions studies is one analytical tool useful for building systems perspective in transitions analysis. In addition, other models, approaches, frameworks and tools that build a systems perspective for conceptual analysis of transitions should be explored for adoption or in concert with the MLP framework. For example, Value Sensitive Design (VSD) is a framework for design of technology that focuses on value investigation; it could supplement the MLP framework to deepen transitions analysis regarding multiple value conflicts that are inherent in systems. When a systems analytical framework is adopted, the second activity involves (2) analysing the transitions situation in its systems. From a systems view, analysis explains not only the transitions situation itself but also its interrelationships within and with its systems. Using the MLP framework in its analytical aspect, numerous interferences of processes are configured, including both societal and technological elements within and amongst multi-levels in socio-technical systems. This enables explaining transitions trajectories developed in past transitions in systems and also probing the transitions dynamics interacting in ongoing transitions in a specific situation. Moreover, configuring the alignment of processes co-evolving amongst multiple levels in socio-technical systems would develop transitions projections. This leads to the third activity of (3) analysing transitions projections and niche pathways. Analysing from a systems perspective places the alignment of processes amongst systems under scrutiny, which yields future transitions projections in a particular transitions situation for niche pathways. At the same time, examining niche pathways may reveal uneven growth quality of niches arising in transitions dynamics – that is, reverse salients. In this prospective aspect of conceptual transitions analysis, a contingent point for a niche breakthrough could be analysed for the tactical stakeholder engagement site to act to reorient transitions. In this way, transitions analysis directs opportunities in terms of timing and space for a design intervention to set strategic directions for niche development to produce a transition.

Identifying reverse salients

Reverse salients develop in the transitions dynamics of future socio-technical contingencies and the adverse results caused by them are usually not yet in effect at present but may materialise in the near future. They characterise the uneven growth quality of niches in systems, which will impede niche development if not addressed by means of a deliberate intervention. This suggests the need to anticipate them before adverse situations develop, and to this end specific approaches must be used. The previous stage of analysing the transitions situation and its pathways has provided a conceptual analysis to understand future contingencies in systems; the current stage involves identifying reverse salients arising in transitions dynamics.

At this stage, the role is defined to identify major reverse salients. The activities in the scope involve (1) diagnosing reverse salients. Reverse salients cannot be seen as such but are reflected in incidents alongside the transitions situation. They are problems inherent in the short term that would constitute reverse salients, and thus must be identified to be removed. In this way, the diagnosis is done by reflecting on contemporaneous occurrences in the transitions situation and, based on their related issues, diagnosing which issues constitute reverse salients. The second activity is to (2) analyse reverse saliency in order to identify the major reverse salients that would critically impede transitions. The analysis of reverse salients would then inform the need for a solution to correct reverse salients, which determines the goals of solutions devoted to mitigating reverse salients. Analysing reverse salients to reveal the criticality of problems also specifies the timing of interventions to be taken before other inferior measures are implemented. When analysing reverse saliency, some methodological approaches could be applied to assist in the identification of major reverse salients. For instance, some qualitative methods describing different depths of reverse salients and other quantitative methods measuring the performance gap of reverse salients could guide the identification of major reverse salients (some methods are introduced in Chapter 2, Section 2.1.2).

Initiating the alternative solutions

The third stage of the design process is initiating alternative solutions. Short-term reverse salients are corrigible; this suggests that problems are solvable when solutions are offered. Mitigating reverse salients has to be handled with practical solutions to realistically solve critical problems before they lead to disastrous outcomes. There is a need for alternative solutions because only by demonstrating other possibilities can viable prospects be projected to stakeholders to enable them to take actions to eventually reorient transitions.

The stage of initiating alternative solutions confines the role of activities to (1) defining the short-term goals of solutions. The analysis of major reverse salients has shown that the goals of mitigation plans are in the short-term future time frame. In this sense, the goals of short-term future planning should fulfil the needs for mitigating short-term future adverse situations. At the same time, solution goals must also be defined in such a way that they are aligned with the long-term sustainability targets in order to consequently reorient transitions towards sustainable futures. Having determined the solution goals, the second activity is to (2) identify the timing of design initiatives. As stated, the solutions must be implemented in a timely manner before adverse situations arise. For this, the previous reverse salients analysis has also shown that an intervention must be initiated before other less undesirable measures interrupt the process. Third, the activity requires (3) seeking a stakeholder tactical engagement site to facilitate transitions. The aim of practically mitigating reverse salients calls for a solution that is a working compromise in equilibrium between conflicting values. This requires the analysis of the alignment of the values and activities of stakeholders in systems from transitions analysis in order to identify a contingent opportunity to facilitate a niche breakthrough. At this stage, the identification of a tactical engagement site for niche efforts may require the design process to return to the earliest stage of analysing the transitions situation. A contingent point may be created when innovations are available from the niche, internal tensions are created within the regime and pressure from changes impacts on the landscape. The opportunity is typically available for a short time and must be seized. In addition, it is noteworthy that short-term future planning for large-scale systems transitions does not imply that interventions can only be large scale. Rather, the scale depends on the adequacy of the solution to mitigate reverse salients, which can be a modest-scale intervention.

Visualising the short-term future planning

When the goals of the strategic design solutions have been determined and the timing and space to initiate them have been specified, the next stage is to visualise the solutions. This is the fourth stage of the design process, that is, the visualisation of short-term future planning. This stage involves the first activity of (1) bringing forward issues of reverse salients to the forefront of transitions. When an alternative solution targeting reverse salients is conceived, the issues have to be brought forward to the present and, furthermore, the solution has to be realised before reverse salients develop. Solutions visualised in tangible forms would increase their visibility and comprehensibility to enable reverse salients to be seen, noticed and clarified. This clarifies the strategic prospects to stakeholders to enable them to facilitate transitions. By bringing forward the reverse salients, the strategic design visualisation has immediate and direct relevance to key stakeholders for their further articulation and actions. In this way, the planning can be operationalised for realising the future. To yield operational effectiveness, the alternative solutions showing available alternatives for developing sustainability have to set guidelines to steer the intended actions as well as give assurance on the feasibility of the solutions to reduce resistance to transitions. This defines the second activity of the visualising role as (2) incorporating guidelines and feasibility of the solutions. The two roles of setting guidelines and providing rationales are described as two individual stages in the design process, which will be discussed separately below.

Regarding the visual formats of the visualisation, the formats can be varied from design drawings to scenarios, videos, films, models and prototypes. To enhance effective communication, the quality of visualisation should also attain a quality of high clarity, high resolution, tangibility and intelligibility.

Setting guidelines for actions

When alternative solutions for short-term future planning are initiated, the next stage is to operationalise the solutions in order to effectively solve critical problems to mitigate reverse salients. To operationalise solutions, they have to offer guidelines. Guidelines are principles to follow in order to ensure that the intended outcomes are produced to mitigate adverse results that would impede transitions. This stage plays the role of setting strategic guidelines for actions. To fulfil the role, guidelines have to be developed under certain criteria and in specific ways.

The stage of setting guidelines for actions involves activities of (1) aligning actions at present with longer-term sustainability targets. Only in this way will the intended actions be able to orient transitions towards longer-term future sustainability visions. The second activity requires (2) setting the guidelines in a clear and specific way to ensure the intended outcomes. This increases the operational effectiveness of the guidelines to strictly govern the intended actions for desirable outcomes instead of other unintended actions. When clear and concrete guidelines are set, they enhance engagement and interaction with stakeholders, as a result increasing their commitment to undertaking change plans. This role is to be incorporated in the previous role of visualising short-term planning.

Demonstrating the feasibility of the solutions

The previous stages have determined the need for alternative solutions to mitigate reverse salients. However, initiating alternative solutions often easily faces resistance to newness. Therefore, practical solutions have to be justified to overcome scepticism. Proving feasibility increases stakeholders' trust and confidence in future changes. Moreover, it demonstrates the viability of a possible prospect of seeing what could also be possible and available in pursuing sustainability targets. This aims at prompting subsequent actions from stakeholders to act at present through developing their own strategies to solve emergent problems.

To achieve a viable solution, it has to take into account the practical considerations and rationales behind the strategic design solutions. To do so, the first activity of this stage involves (1) conducting analysis to support the viability of the solutions. Analyses may provide statistical and technical support as well as detailed document analysis relevant to support the solutions. The proof aims at demonstrating the practical and future feasibility of the alternative solutions. The corroboration of logical supports demonstrates that the solutions have been taken into practical consideration and they possess real and practical functions. The second activity is (2) explaining the rationales in a comprehensive way to enable stakeholders to deliberate on how to facilitate the solutions to achieve the sustainability targets. In this way, the reasoning of how the solutions have been arrived at has to be understood by key stakeholders. This gives stakeholders an understanding of why and how the solutions have been reached and hence enables stakeholders to deliberate on their own best plans for transitions. Clearly expressing the rationales behind solutions eventually facilitates stakeholders' immediate actions and strategies to mitigate reverse salients.

To give a demonstration of the new design model that has been improved with the new insights, the two case studies are revisited. This illustrates a complete process of how to create short-term future planning guided by the six stages and carried out in an integrative and iterative process. The table below explains the respective activities required to fulfil each of the roles in the design process (Table 10. Demonstrating the application of Strategic Design for the Short-term Future to the two case studies).

Table 10. Demonstrating the application of Strategic Design for the Short-term Future to the two case studies.

	Case study 1	Case study 2
Analysing the transitions situation	▪ MLP for a systems perspective and VSD to assist in transitions analysis ▪ Alignment of processes in systems amongst the heritage constituency, Aalto University Properties and Aalto University Presidency is analysed ▪ Transitions projections and niche pathways of solar PV in a heritage situation in its energy systems are mapped using MLP	▪ MLP for a systems perspective ▪ Alignment of processes in systems amongst the measures of the Ministry of Agriculture and Forestry, fish farm licensing, fish farmers' responsibility and fish consumers' interest in consuming locally farmed fish is analysed ▪ Transitions projections and niche pathways of the Finnish salmon trout transitions are mapped in its aquaculture systems using MLP
Identifying reverse salients	▪ Reverse salients are diagnosed – the major one is that the aesthetic and heritage values are opposed to solar PV installation ▪ Information attained in this stage is connected to the previous stage for deeper transitions analysis	▪ Reverse salients are diagnosed – the major one is the high investment costs of offshore aquaculture ▪ Information attained in this stage is connected to the previous stage for deeper transitions analysis

Initiating the alternative solutions	▪ Returning to the previous two stages to define the goal and timing of the solution ▪ The solution goal is to demonstrate an alternative solution for installing solar PV panels on Dipoli ▪ The timing of the design intervention is before the implementation of other less desirable renovation measures by 2015-16 ▪ The site for stakeholder engagement is a working compromise between the conflicting values of preservation, modernisation and aesthetic values	▪ Returning to the previous two stages to define the goal and timing of the solution ▪ The solution goal is to offer viable means of investing in offshore aquaculture and maintaining water quality ▪ The timing of the design intervention is before the release of the ASC results within one to two years ▪ The site for stakeholder engagement is an interlevel that aligns the interests and values of fish farmers, fish consumers and the market
Visualising the short-term future planning	▪ Bringing forward issues of experts' recommendations ▪ Incorporates guidance and rationales behind the optimal solution of siting solar PV panels on Dipoli ▪ Visualising the strategic design solution in an architectural rendering	▪ Bringing forward issues of the ASC ▪ Incorporates guidance and the rationales behind the solution ▪ Incorporates guidance and the rationales behind the optimal solution of developing sustainable offshore salmon trout aquaculture in the Baltic Sea ▪ Visualising the strategic design solution in a fish certification
Setting guidelines for actions	▪ The guidelines are based on the goal defined in the previous stage ▪ This stage works together with the next stage ▪ Aligning the optimal way of siting solar PV panels on Dipoli with the campus vision ▪ Setting clear and specific guidelines for siting solar PV to guide Aalto University Properties in its intended action of solar PV installation in a heritage building in a culturally sensible way through high resolution rendering	▪ The guidelines are based on the goal defined in the previous stage ▪ This stage works together with the next stage ▪ Aligning fish farmers' action of developing sustainable salmon trout aquaculture with the national production goal for 2020 ▪ Setting clear and specific guidelines for siting offshore fish farms, adopting the recirculating nutrients concept and guiding fish consumers' fish choices by means of eco-ratings classification
Demonstrating the feasibility of the solutions	▪ This stage works together with the previous stage ▪ The feasibility of the solutions is based on the goal defined in the previous stage ▪ Technical analysis to support solar PV arrangement on the rooftop ▪ Explaining the rationales behind the solution in a comprehensible way to enable Aalto University Properties to understand how to proceed with solar PV installation by detailing the arrangement	▪ Document analysis to support sustainable salmon trout aquaculture ▪ Explaining the rationales behind the solution in a comprehensible way to enable fish farmers to understand how to develop sustainable salmon trout aquaculture and fish consumers how to make ecological choices on the basis of three eco-rating principles

In conclusion, addressing reverse salients has directed new criteria and orientation for strategic design and a new design approach has been developed. At this stage, a new design model formulated in a six-stage process has been introduced to guide the development of short-term future planning to identify and overcome problems emerging in the near future. A noteworthy feature of this design model is that it does not intend to guide a final design solution that would be the best or the only possible way to achieve sustainability goals. Rather, it guides the development of a solution that is an optimal working solution for the situation at the time in question and which is also in equilibrium between multiple interacting and conflicting values.

6.3 Chapter summary

This chapter has developed a new strategic design approach for creating short-term future planning to identify and overcome problems emerging in the short term in order to mitigate reverse salients. The resulting design approach is explained in a strategic design model, namely the Strategic Design for the Short-term Future, which formulates design principles to comprehend specific transitions situations and arranges a six-stage design process for design practice.

The first section (Section 6.1) has explained the development and improvement of the initial theoretical proposition based on the six new insights captured from case studies. Three main improvements are discussed. They are: first, the titles of the three stages are rephrased to increase the clarity of their roles. Second, a new stage is added, that is, visualising short-term future planning, which is found to be a vital stage in the design process. Last, the sequence and structure of the design process is finalised. Section 6.2 presents the resulting new design model of the Strategic Design for the Short-term Future. The new model comprises six stages: analysing the transitions situation, identifying reverse salients, initiating alternative solutions, visualising short-term future planning, setting guidelines for actions and demonstrating the feasibility of the solutions. The design approach featuring an integrated model is arranged in a consecutive sequence and an integrative and iterative approach. The last part of the section gives a demonstration of the new design model applying to the two cases to illustrate the complete design process of each case. Finally, the case revisit, confirming the new design model, has brought closure to this research project. The Strategic Design for the Short-term Future model is a practice-relevant design approach to guide design practice. The model, which is an empirically valid theoretical framework with a strong theoretical underpinning and empirical evidence, is also expected to be applied to more and future sustainability transitions research.

7. Discussion and conclusions

Reviewing the research aim and research questions

This research focuses on anticipating and overcoming sustainability transitions obstacles in the short-term future. This design research builds on the current research on design for sustainability at the systems level by adopting a systems perspective and integrating it with transitions theories. The research contributes to the underexplored research on developing short-term future planning by applying the concept of reverse salients. This discussion reviews whether all the research questions have been answered to achieve the research aim. The three research questions seeking to achieve the research aim are restated as follows:

1. Which are the critical phenomena of systems transitions that prevent design for sustainability from achieving its objectives?
2. How can design for sustainability identify and solve problems that are emerging in the short-term future?
3. What form of guidance can be provided for designers to meet short-term future challenges in sustainability transitions?

The first question enquires about the critical phenomena of systems transitions that prevent design for sustainability from achieving its objectives. The answer is sought by reviewing transitions literature and technological transitions in the field of social studies of technology (Chapter 2, Section 2.1). The review reveals the critical phenomena of systems transitions, which are found to be problems that emerge in the near future. They pose a forthcoming threat to systems transitions if a deliberate intervention is not taken; however, the problems are not easy to deal with and that may have restricted design to facilitate transitions. In theory, problems emerging in the near future are conceptualised as reverse salients (Hughes, 1983:79-105). Reverse salients have to be removed from transitions, as otherwise they will lead to critical situations that hamper overall systems transitions. The great challenge that reverse salients pose to design is that they are unseen problems that have to be identified; even if they can be seen, they are not easily handled, which demands an alternative approach to overcome them. Having presented the theoretical concept of reverse salients and adopted it in the two case studies in this research, the critical phenomena of transitions in their systems become apparent. In Case study 1, the reverse salients are reflected in the architectural experts' opinions that the heritage rooftop is inaccessible for siting solar PV. If this situation is left unaddressed, it would lead to a critical situation involving the categorical rejection of solar PV installation in the heritage building and, furthermore, an overall rejection of ecological modernisation across all heritage buildings. In Case study 2, the reverse salients are reflected in the fish farmers' aspiration to secure ASC certification. Again, if the case is left unaddressed, it would lead to a critical situation in which no investments are made in offshore sustainable salmon trout aquaculture and, furthermore, curb overall sustainable aquaculture in Finland. As shown by the two case studies, the theoretical concept of reverse salients can be used to indicate case by case the critical phenomena of systems transitions – that is, the problems emerging in the short-term future.

The second question seeks ways to enable design for sustainability to identify and solve problems emerging in the short-term future. To answer this question, two case studies are conducted and the design processes are systematically analysed to examine how the cases identify and solve problems that emerge in the short-term future (Chapters 4 and 5). The analysis indicates that a combination of specific design activities and particular methods is applied. They include analysing transitions situations through using MLP and VSD analytical tools to examine transitions dynamics and analyse problems of future contingencies. In addition to conceptual analysis, empirical investigations are also managed through field work. In the two cases, a mixture of methods including field observation, interviews, on-site prototyping, archival research, document review and technical analysis are applied. The field work deepens contextual understanding of specific transitions situations to aid in fathoming issues of reverse salients in their contexts. These analyses and investigations gradually expose the needs for solutions to tackle the identified problems. Visualisation is a vital activity in the design process, as it brings forward reverse salients to the forefront of transitions to make them visible at present. At the same time, alternative design solutions are also visualised. In order to overcome the identified problems before critical situations develop, the visualisation has to be operationalised by incorporating guidelines and the rationales behind the solutions for actions. Through specific design activities and applying the methods, Case study 1 succeeds in identifying the aesthetic and heritage values opposed to solar PV installation as the major reverse salient. This is overcome by visualising a demonstration of an alternative way of siting solar PV in the heritage building through a strategic design visualisation. This proves that siting solar PV in a heritage building is not at odds with the preservation of cultural heritage, but can be done in a culturally sensible way. Case study 2 identifies the reverse salients as the high investment costs of offshore aquaculture. These are overcome by visualising a viable alternative for investing in offshore aquaculture to fish farmers and the availability of consuming locally, sustainably farmed fish to fish consumers. The resulting visualisation demonstrates that aquaculture can be developed in a practicable and sustainable way. Moreover, the quality of visualisation is also an important aspect of increasing operational effectiveness. Throughout the process, design activities of analysing transitions, identifying and correcting reverse salients, setting guidelines and demonstrating the feasibility of design solutions are taken in combination with varied methods. Overall, the identification and solving of problems emerging in the short term is achieved by going through a design process that applies a combination of specific design activities and particular methods.

The third research question inquires about the form of guidance provided to designers to meet the short-term future challenges in sustainability transitions. In order to enhance design that meets new challenges – the short-term future challenges in sustainability transitions – the form of guidance should have a solid theoretical underpinning to sufficiently explain the phenomena of ongoing transitions situations as well as comprehend problems inherent in the short-term future. In addition, the approach should also be empirically valid in order to confirm that the design approach is adequate to guide the design process to identify and overcome problems emerging in the near future. To provide the answer, a literature review is conducted to draw theoretical insights that offer design implications for design practice. Afterwards, case study is adopted as a research method to evaluate and develop the theoretical insights (case study method and procedure is conducted in Chapters 3, 4 and 5). The case study method is also used because it is particularly suitable for exploring new research areas – that is, the short-term future challenges in sustainability transitions whereby the concept of reverse salients is also newly adopted to develop a new design approach for these challenges. Given a new design approach, a design process is organised and the design activities in each stage of the process are clearly defined in order to show the process of creating strategic design solutions for short-term future planning in detail and in stages. The design process model is named Strategic Design for the Short-term Future (achieved in Chapter 6). Finally, the form of guidance provided for designers is a theoretically based and empirically tested design model consisting of a six-stage design process to precisely guide designers to succeed in meeting the short-term future challenges in sustainability transitions.

The above review has explained how the three research questions are answered. This research targets sustainability transitions obstacles in the short-term future that prevent design for sustainability from achieving its objectives. To enhance design practice, a new and sufficient design approach to aid in anticipating and overcoming the problems is systematically developed in this research, guided by the three research questions. When all three of the research questions are answered, it can be confirmed that the research aim is fulfilled. As a result, this research addressing sustainability transitions obstacles in the short-term future has developed a new strategic design approach for short-term future planning against reverse salients which enhances design for sustainability at the systems level.

Practical contribution: Developing a new strategic design approach for sustainability transitions

This research has suggested an alternative design approach to facilitate sustainability transitions at the systems level by targeting a different transitions challenge. The challenge refers to anticipating and overcoming sustainability transitions obstacles in the short-term future, which results in a new design process model called Strategic Design for the Short-term Future. The new approach targeting the transitions challenges of the short-term future against reverse salients is found lacking in current research, and thus it contributes to design research for sustainability. The Strategic Design for the Short-term Future model is theoretically based and empirically valid. The model has a strong theoretical underpinning drawing from two fields of knowledge as well as extensive empirical evidences captured from case studies. The integrated knowledge adequately explains the phenomena of ongoing transitions situations as well as sheds light on problems inherent in the short-term future. To further achieve its guiding purpose, the new model organises a design process to guide design practice in the real world for sustainability transitions. The process consists of six stages with clearly defined roles and activities in each of the stages in order to precisely guide design to identify and overcome problems in the short-term future. This contributes to the practical value of the new design process model for short-term future challenges in sustainability transitions.

In design for sustainability research, the majority of design research generates strategic visions of the long-term future and, accordingly, designs long-term strategic actions to implement far futures. This has been made evident from reviewing the research on design for sustainability (Chapter 1). In design practice, most designers create concrete solutions to problems in present situations, even though bigger problems are emerging behind the ongoing evolving transitions. As a result, their designs very often end in failure. In a systems transition, producing a change requires progressive interventions to gradually overcome obstacles in transitions pathways due to the transitions dynamic in systems. Obstacles emerging in the short-term future – which have been comprehensively studied in this research – are more challenging. These explain that design for sustainability cannot be limited to merely generating high-level, far-fetched visions that may lack operational effectiveness in the short-term or only solve problems involving present situations without strategic importance. Seeing this divide, this research focuses on the midway between the two, committing to short-term future challenges by adopting the concept of reverse salients. This midway view directs an alternative design approach that connects long-term goals and the present-day actions in order to solve problems within the future situations that can be projected. In other words, the alternative approach develops design solutions whose present operational effectiveness fulfils short-term future goals in order to achieve longer-term visions. The new view provides an alternative design effort to the global joint forces involved in the arduous task of tackling environmental challenges.

This new design approach opens up a new realm of possibility for designers to facilitate sustainability in a different manner. By virtue of this approach, it is now possible to assist designers to take greater responsibility for sustainability and help them achieve the intended, desirable outcomes. This new strategic design approach – which has operational importance for the short-term future – may represent a view on design for sustainability. As studied, in creating an operational concept of strategic design, the quality of visualisation is also an important criterion to increase operational effectiveness. Achieving high visualisation quality requires the skillsets of producing clarity, intelligibility, precision, high definition, realness and other similar qualities. Earlier in this research, the role of the researcher – that is, my role – has been clarified. I have stated that due to my background as a practising designer, the design expertise I have obtained has enabled me to produce high-quality strategic design visualisations in the two case studies. This observation perhaps offers a chance to reflect on how to approach design for sustainability. Since the design thinking concept was introduced to non-designers in the mid-2000s (Johansson-Sköldberg, Woodilla and Çetinkaya, 2013), the ideal of making changes – whatever organisational or societal changes – has definitely opened more possibilities to enable non-designers to approach design for sustainability. However, might it at the same time have restrained the power of design to pursue sustainability if design competence is not taken into consideration? This research has explained the importance of design competence to produce strategic design. In the research, the need to build design with a systems perspective and integrate transitions knowledge with design has been emphasised; it would be equally important to maintain and increase design competence. This approach would perhaps be an effective way to support design for sustainability without procrastinating on sustainability transitions.

Now, with this new design process model readily at hand, it is expected that the model could be practically applied to a diverse range of transitions situations in order to experiment with tackling challenges in the near future in society. For example, the critical phenomenon of the slow and difficult transitions situations of electric vehicles in renewable energy systems is ubiquitous everywhere. With this strategic design model, the reverse salients of high costs or lack of infrastructures could be anticipated and analysed in-depth to develop practical correction plans. An alternative meaningful area would be to investigate the transitions situations in building resilience at the societal level. The design model could bring forward problems inherent in future vulnerabilities to the present and offer short-term future planning to avoid threatening circumstances that may lead to the worst outcomes.

Theoretical contribution: Applying the concept of reverse salients to design research

The concept of reverse salients has not been adopted by design research; however, it has relevance to developing strategic design that aids the reorientation of transitions towards achieving sustainable futures. In a nutshell, the reverse salients concept refers to problems inherent in the near future that would cause future adverse outcomes (detailed study is presented in Chapter 2, Section 2.1). Adopting the concept facilitates anticipating and overcoming transitions problems in the short-term future in sustainability transitions. Over three decades, the analytical strength of the reverse salients concept has been adopted for studying systems growth in large technical systems. Bringing the concept to design research offers design a conceptual understanding of the emergent transitions challenges in the short-term future, which informs an alternative way of developing a design approach to meet short-term future challenges. Simultaneously, by adopting reverse salients, this research has also advanced the reverse salients concept in the pragmatic aspect.

The conceptual understanding of reverse salients offers an explanation of how reverse salients develop in the near future. Furthermore, the concept can be taken forward to pragmatically identify, analyse and ultimately solve problems in the short-term future. On the one hand, the analytic and methodological process of analysing reverse salients offers insights into anticipating reverse salients. On the other hand, when the concept of reverse salients is integrated with strategic design insights in the creation of design solutions, the concept of reverse salients becomes operationalised to overcome problems in a practical manner. Adopting the concept of reverse salients simultaneously enhances design research on short-term future challenges and advances the pragmatic aspect of the concept. The theoretical contribution of this research in advancing the reverse salients concept for sustainability is evidenced by the two case studies. In both cases, major reverse salients are diagnosed. In case study 1, the reverse salients of the aesthetic and heritage values being opposed to solar PV installation are defined as major ones for correction. In case study 2, the reverse salients of high investment costs of offshore aquaculture are defined as the major ones in need of correction plans. When reverse salients are identified, the analyses of reverse saliency in both cases define the goals and timing of design solutions, which suggest more concrete correction actions to fight against reverse salients. In case study 1, the goal is to demonstrate an alternative solution for installing solar PV panels on Dipoli before other less desirable renovation measures are implemented. In case study 2, the goal is to offer viable means of investing in offshore aquaculture and maintaining water quality before the ASC result is released. To overcome reverse salients in both cases, two strategic design visualisations are developed.

In this research, the framing of reverse salients has opened a new space to develop a new design approach for sustainability. Besides developing a new design approach, the theoretical concept may offer an alternative perspective to understand design problems. Design problems have been actively studied for almost half a century to develop design methods of problem solving (Cross, 1993). There are studies from the design field on the purpose of design methods (for example, Archer's Designerly Ways of Thinking (1979) and Cross's Designerly Ways of Knowing (1982)) and there are also concepts from other fields to understand the nature of design problems for developing the methods. Amongst the major design problem concepts, the most prevalently cited one should be “wicked problems” by Horst Rittel and Melvin Webber (1973); the concept still has great relevance today when addressing climate change. In their study, they understand design problems as wicked problems in social planning because they are similarly ill-defined. The alignment places the design process of solving problems under scrutiny, which has developed their concept of the argumentative method to solve problems (Rittel and Webber, 1973; Rittel, 1988). Yet in similar way, if the concept of reverse salients is adopted to see design problems, what could be understood from the concept when applied to problem solving? Investigating the alignment would be a daunting task and is out of the scope of this research, yet one quick observation can be made about the key characteristic of reverse salients, namely, their unforeseen nature (a set of characteristics defining reverse salients is attempted in this research in Chapter 2, Section 2.3.1). One means of mitigating problems in the far future is provided by Buckminster Fuller’s concept of anticipatory design (1969), which is useful in the implementation of long-term resource regeneration visions. The unforeseen characteristic of reverse salients in the implementation of visions in the shorter term may add a new dimension to exploring design problems and, furthermore, systematically developing new problem-solving methods to be applied in other fields.

Limitations of the research

There are several limitations of this research. The first limitation is the two-case study in this research. Application of the new design approach to two cases may have limited the applicability of the approach to more transitions cases for sustainability. However, the research strategy of settling on a two-case study was deliberately planned at the beginning of the research. In this research, case study is adopted as a research method to develop the original proposition. In this way, different cases are chosen to yield richer theoretical insights from their distinctive empirical evidence rather than to be representative of a specific population, as statistical sampling would require (Eisenhardt and Graebner, 2007). This deliberation justifies a small case study for this research, provided that rich and unique empirical evidence can be captured from the cases.

In spite of this deliberate research strategy, a two-case study may still produce bias; if bias is not taken into consideration, it will prejudice the research findings, thereby threatening the quality of the research (Kopec and Esdaile, 1990; Norris, 1997). From the outset, the potential sources of bias deriving from the two-case study have been estimated and some rules are set up accordingly to eliminate its effect on research quality. First of all, in the case selection process, a set of robust selection criteria for choosing cases that are appropriate for applying the theoretical proposition is drawn up. The selection criteria minimise the bias that would have a negative effect on accuracy in the case analysis. Governed by a meticulous case selection process, both cases fulfil the case selection criteria to ensure that the case analyses are valid for theoretical proposition development. Besides the potential selection bias, the analysis of the causal relationship amongst the theoretical insights and empirical evidence may also produce a bias. To accurately analyse the case findings, the theoretical proposition available in this research for case study has clearly described theoretical insights drawn from literature. The concrete theoretical proposition makes the analysis explicit, which enhances the achievement of higher accuracy to ensure that impartial analysis conclusions are drawn. Moreover, a systematic and logical case study research procedure is conducted to ensure theoretical insights and empirical evidence are thoroughly analysed and in iterations. The rigour of the research procedure helps eliminate the analysis effect that would potentially bias the research result.

The second limitation addresses the issue of the cultural specificity of the two cases. Both cases are conducted in Finland – Case study 1 is the Finnish renewable energy case conducted in Espoo in Finland and Case study 2 is the Finnish sustainable salmon trout case in the Baltic Sea in Finland. Application of the theoretical proposition to two local cases may appear to have restrained the validity of the proposition in terms of applicability to other cultures in the wider international context. To eliminate this culture effect that might bias the research result, it is essential that the two cases are strictly selected based on the case selection criteria as mentioned above rather than a culture decision. In addition, the two cases are typical of contemporary transitions phenomena within real-life contexts, which are not limited to Finland but are seen everywhere in the world. Transitions impasses in renewable energy transitions and sustainable aquaculture transitions are ubiquitous in many other sustainability transitions cases all over the world that are not specific to only one culture. When measuring the phenomena, the focus is placed on the transitions context wherein the analysis and interpretation are guided by the concrete and explicit theoretical proposition, disregarding the cultural practices involved in the phenomenon. Having stated the criteria behind selecting the cases and the focus of analysis, the cultural effect that may arise from the two local cases is removed to a great extent.

The third limitation concerns the role of the researcher in this research – that is, my role as the single researcher. I played the role in major parts of this research project,[11] which includes collecting and analysing data, creating design solutions, developing the new design model, evaluating results and making conclusions and so on. This single researcher role may potentially cause bias in self-evaluation. To eliminate self-evaluation bias, some precautions have been taken. In the process of data collection and analysis, a strict case study procedure is constructed for actual data collection. Also, the data is obtained from multiple sources and through different methods. In this way, multiple sources of evidence help avoid biased data. In addition, the descriptions of the cases are drafted to be detailed and in-depth, which aims at

[11] With only two exceptions – first, in Case study 1, a team of three researchers including me worked together on the literature research, field work and solar array design. Second, two journal papers were co-authored with two professors discussing the respective cases (Case study 1 and Case study 2).

ensuring that the interpretations remain impartial and that the analysis is accurate, based on data but not the researcher's subjective view. Without acknowledging researcher bias, affirmative research results would be easily induced by researchers. A self-critical and constructive approach has been taken to evaluating results and drawing conclusions with a view to improving the quality of argumentation. Furthermore, the two journal papers published earlier (mentioned in Chapter 4) have been peer-reviewed, and these external comments provided more objective discussions that were useful in improving research quality and facilitating data validation. Overall, these measures have helped mitigate against self-evaluation bias arising from a single researcher. Still, at this early stage, the newly developed design approach has to be objectively evaluated by other researchers.

The above has acknowledged several potential sources of bias that may have affected the validity of this research. In view of the potential bias, appropriate rules are set in an attempt to manage the bias effect on research quality for an accurate, reliable and valid research result.

Actually, there could be one more limitation that may have affected this research result, but this limitation does not minimise the research validity, unlike a potential source of bias. On the contrary, it may inspire further development to constantly build on this research. The limitation to be discussed here is posed by the transitions theories adopted in this research. At the beginning, in contemplating design shortfalls for sustainability, transitions theories and strategic design studies are adopted to enhance design for sustainability. Transitions theories have deepened the understanding of the nature of problems in transitions, particularly the challenges in short term. Tackling the short-term future, this new strategic design model adopts strategic design insights to solve problems arising in transitions by offering alternative solutions. In the design research community, there are also other design theories on problem solving that may be equally as beneficial to integrate with transitions theories. For example, the Frame Creation design model introduced by Kees Dorst (2015) creates approaches to solving complex and networked problems through reframing problem situations. What if the Frame Creation model were adopted to fight reverse salients through reframing problem situations arising in the near future? This research has deepened the understanding of problems in transitions without limiting the theories of transitions to only the new strategic design model; other design theories can be adopted to further design models of short-term future problem solving to build on the transitions knowledge attained in this research.

Future research

The first recommendation is to engage in further future research by applying the new design model to more case studies. As discussed earlier, this research is based on a two-case study design. Planning for a two-case study, development is supported by a justified research procedure wherein theoretical insights and empirical evidence of the cases are analysed in depth and in iterations. The research result indicates early signs that the approach can be taken up to tackle short-term future challenges in transitions. Yet, even though a valid design model is attained, this theoretically underpinned and empirically valid design model is still in the infancy of its development. The model for short-term future challenges can be considered innovative, as it has established an alternative design approach for sustainability transitions. At this initial stage, the innovative design approach has laid strong theoretical groundwork for the current research on design for sustainability to continue to develop the model. The next step is to practically implement the design model in more and different real-life transitions situations in order to enhance its performance and further its validity for wider empirical applications to facilitate sustainability transitions.

Second, more future research applying the concept of reverse salients is recommended. The concept of reverse salients reveals that there is an urge to fight transitions challenges in the near future, which yields an opportunity to attempt a new design approach for short-term future planning. This contributes to current research by suggesting new steps forward as an alternative perspective to understand transitions challenges and develop a new design approach to sustainability transitions. Based on the supportive research result, it is worth extending the concept to explore different design approaches in future research to enhance design for sustainability at the systems level. In other fields of technological systems research for sustainability, the concept is being adopted more widely, such as in business management, technology studies and energy policy. The theoretical implications of the reverse salients concept have given rise for these fields to develop diverse analytical and methodological approaches to enhance systems transitions. This reflects the beneficial function of the concept for systems transitions (these studies are discussed in Chapter 2, Section 2.1.2). The emergent adoption of the reverse salients concept in other fields can be seen as an indication of a meaningful direction for design research to adopt the reverse salients concept to also develop different analytical and pragmatic approaches, models, frameworks and tools of design for sustainability.

Third, a systematic way to identify major reverse salients could be useful and effective for developing short-term planning to mitigate them. In the two case studies, reverse salients likely develop adverse situations in the near future are reflected on contemporaneous occurrences at transitions situations. Based on their related issues, issues constituting reverse salients are analysed to diagnose major ones (stage 2 of the design process model, Strategic Design for the Short-term Future). To enhance diagnosis, a more systematic method to select final reverse salients should be recommended. In other fields, there are a few methods to guide to analyse reverse saliency. They include qualitative methods to describe and compare various depths of reverse salients and quantitative methods to measure the performance gap of reverse salients. The methods identify which reverse salients are becoming critical to hold back transitions (in Chapter 2, Section 2.1.2). In this research, a groundwork could be utilized as one direction to enhance the identification of reverse salients. In Chapter 2, three structural problems in socio-technical systems are analysed and their characteristics are defined (Table 1. Characteristics of problems in socio-technical systems, in Section 2.1.2). The analysis characterises three types of problems – persistent, unforeseen and critical – that may develop into reverse salients. On this basis, the analysis could be developed as a measure to compare the extent of the issues of how persistent, unforeseen and critical are they at specific transitions situations and hence, shows a spectrum for identifying major reverse salients. This recommendation would expand design research to apply reverse salients as a methodology to develop more structured methods to systematically analyse reverse salients.

Fourth, making "actor" as a focus of study on reverse salients for future research. This research addresses interdependent relationships in systems, however, "actor" element implicating in transitions dynamics is not explicitly made to focus. To recapitulate, Case Study 1 concentrates the focus into the interdependent relationships between cultural heritage preservation, ecological modernisation and the aesthetic quality of preserved heritage. The focus of Case study 2 also keeps to systems interdependencies to examine the interacting dynamics between marine ecosystem, farmed fish production growth and fish market for sustainably farmed local salmon trout. While reviewing the design process of the two cases, the knowledge of the key actors and their perception have played significant roles in constituting reverse salients. Moreover, the identification of reverse salients in the two cases has been guided by key actors for their views are conflicting with other actors. These conflicting views interacting in systems become critical to cause reverse salients to hamper transitions. Therefore, putting explicit focus on different actors would deepen the understanding of multiple conflicting values inherent in systems, which would enhance the identification of reverse salients. This poses potential area to be explored for future research.

The last recommendation for future research is to explore other tools, methods and approaches for comprehending systems transitions in addition to the multilevel perspective (MLP) framework. This research uses MLP framework at the first stage of the new design process model for a conceptual analysis of transitions. This application fulfils the design process by providing background understanding to investigate reverse salients. In this research, MLP framework is selected for its established theory to build a multilevel perspective to analyse transitions situations in systems. Since its introduction in the early 2000s, it has been adopted by many transitions researchers. Moreover, the framework has also been constantly improved and developed based on comments and criticisms from other scholars. In this research, the analytical and prospective strengths of MLP are used to map dynamics of interconnectedness in systems and, probe niche pathways and future transitions projections. These qualities are supportive to study issues of reverse salients inherent in systems that comprise high complexity of dynamics. However, in concert with MLP, Value Sensitive Design (VSD) is also applied in Case Study 1 to deepen transitions analysis regarding multiple value conflicts that are inherent in systems. In Case Study 2, the resulting design solution is positioned at niche-regime inter-levels leveraging interlevel dynamics as an essential source for systems change. This reflects that a framework without limiting to a three-level systems structure may provide a broader perspective to study reverse salients and develop different alternative solutions against reverse salients. In this research, MLP has offered a good start to build a systems approach for transitions analysis while more exploration is seen to be beneficial in broadening opportunities for systems transitions. Exploring other theories for transitions analysis in addition to MLP is suggested for future research.

Conclusions

To close this dissertation, I look back at the case of the Low2No project in Finland (introduced in the prologue), which served as my starting point for this doctoral research. In retrospect, can the unforeseen withdrawal of the construction companies in Low2No have been foreseen and mitigated? Having conducted this research work, a new design approach targeting short-term future challenges in sustainability transitions has been explored, which tends to give a supportive answer to the question. The new design process model represents an important research result to further the transitions process towards realising sustainable futures. However, on further reflection, I have realised that the integration of knowledge is equally important for this research. Transitions theories do not lead directly to the creation of short-term future planning and, similarly, strategic design knowledge does not lead directly to anticipating problems inherent in the short-term future. It is the integration of the two fields of knowledge into a coherent whole to achieve integrated knowledge; it is the logical and systematic research method and procedure conducted in argumentative rigour for research quality. This is a real treasure that I have found during my doctoral journey.

This study ends in the year when the Bauhaus celebrates its centenary. Since the Bauhaus principles were established, design knowledge has been enhanced greatly through design research and design practice for social and environmental sustainability. In this decade, design has also been expanded to the systems level to facilitate systems-scale transitions for sustainability. Meanwhile, I hope this research work has enriched design for sustainability and would make a modest but important contribution to advancing design in concert with current design research towards realising sustainability futures.

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Reverse salients, the term conceptualises problems inherent in the near future that would cause future adverse outcomes. They are problems that are not seen at the present; even if they are projected, they are not easy to solve. These obstacles to sustainability transitions in the near future have to be anticipated and progressively overcome in order to further the transitions process before they lead to critical situations that hamper overall systems transitions. Focusing on the short-term future posits an alternative design approach.

This dissertation develops a new design approach, namely Strategic Design for the Short-term Future, through integrating transitions theories and strategic design studies. The research contributes to a new research area of exploring an alternative strategic design with anticipatory strength as well as operational effectiveness in order to pre-empt future adverse results. To build theory for guiding design practice, two case studies involving renewable energy transitions and sustainable aquaculture transitions are conducted. Consequently, the new strategic design enables designers to anticipate and overcome problems arising in the short-term future – that is, design against reverse salients.

9789526087160

ISBN 978-952-60-8716-0 (printed)
ISBN 978-952-60-8717-7 (pdf)
ISSN 1799-4934 (printed)
ISSN 1799-4942 (pdf)

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