1 Introduction

This thesis is positioned within the discipline of design research. According to Nigel Cross, one of its pioneers, design research 'includes the study of how designers work and think, the establishment of appropriate structures for the design process, the development and application of new design methods, techniques and procedures, and reflection on the nature and extent of design knowledge and its application to design problems' (Cross 1984). Starting point of the research presented in this thesis is the observation that design theory has been developed and implemented to address the problem of unsustainable levels of consumption, but that so far efforts have not been sufficiently effective. In spite of over 20 years of 'sustainable design', new product development is still contributing to increasing rather than decreasing levels of resource consumption.

According to the World Wildlife Fund Living Planet Report (Polland 2010), human demand on the biosphere has more than doubled between 1961 and 2007. In the late 1970's, the world's ecological footprint has surpassed the earth's bio capacity, and today, humanity uses the equivalent of 1,5 planets to provide the total of resources used and absorb the waste generated (Global Footprint Network 2010). Even moderate United Nations reports predict this excess to have increased to two planets by 2030. The European Union (EU) is already at this 2-planet level today (EEA 2012). In other words, to reach a more sustainable balance between consumption and the planet's capacity, average resource consumption levels of European countries should be decreased by at least 50% compared to 2010 levels. Because there is a close relationship between product design and change in society, as will be argued below, efforts in the design discipline are already showing motivation to address unsustainable consumption levels. This has led to a demand for, and emergence of a realm of design research that is in this thesis grouped under the term 'sustainable design'.

1.1 Sustainable design

Because of its wide variety in interpretations, the term sustainability is avoided as much as possible in this thesis. Rather, focus is on the specific concern of resource depletion and the observation that Western societies are using more resources than the planet can sustainably provide. If society continues at this rate of resource consumption, following generations will face serious problems for their survival and already now, societies in other parts of the world are noticing the effects of resources depletion on their endurance (Flora 2010). In this thesis, sustainability is narrowed down to a situation in society in which resource consumption is in balance with the ecosystems' capacities. This balance cannot be clearly defined, but what is certain is that current levels of resource consumption of the EU are well above those required for such a balance.

Focusing yet more, central to the thesis is direct resource consumption in households. This focus stems from the 7th Framework Living Lab project (Bakker et al. 2010) that this research was part of. Direct resource consumption involves the resources delivered to households directly through infrastructures, being gas, electricity and water. Direct is here contrasted with indirect resource consumption that takes place elsewhere for the production of products consumed by the household. In Europe, households account for approximately 25% of society's direct resource consumption, in which other sectors are industry, transport and services (EEA 2013). In the thesis, Europe is used as the target area, but most of the time The Netherlands is used as an example of a European country. The Netherlands has an ecological footprint that is even higher than the European average, requiring 3,5 times its fair share of bio capacity (Global Footprint Network 2010). This means that for a balance, reductions are required in at the order of over 70%.

Like sustainability, design too is a fluid term with myriads of interpretations. Economist Herbert Simon, now seen as one of the founders of the design research community (Cross 2006), has described design in very general terms as 'devising courses of action aimed at changing existing situations to preferred ones' (Simon 1996: 111). When talking about sustainability, these ideas of change and a difference between existing and preferred situations are central. Situated in an Industrial Design Engineering department, the focus of this research is on the relation between industrial product design and household resource consumption. Industrial product designers are trained to develop consumer products (products, systems, services) for mass production (Boeijen and Daalhuizen 2010). In the direct resource consumption of households, these artefacts (be it thermostats, taps or dishwashers) play a crucial role, for it is through them that people consume direct resources like energy and water.

When aiming to reduce household resource consumption, industrial product designers (from now on referred to as 'designers') have been identified as possible initiators of desirable change. One, because mass consumer products and new product development are implicated in (growing) resource consumption of households (Papanek, 1971; Thackara 2005); in other words, design receives part of the blame for the problematic situation society is in. And two, because product design is viewed as a motor of change in society and therefore considered a means to facilitate the change that is needed to reduce consumption levels (Thackara 2005; Manzini 2006; Ehrenfeld 2008; Fry 2009).

1.2 Social practice theory

Previous experiences have shown, however that the relation between design and changes in household resource consumption is not straightforward. Reduction targets are not always achieved and efforts can even be counterproductive. For example, washing machines have become more water and energy efficient, but in parallel, washing frequencies increased by 20 to 25% (Verbeek and Slob 2006). The same counts for light bulbs, where a 50% increase in energy efficiency was countered by a fourfold increase in consumption of light (Herring and Roy 2007). Moreover, effects of (new) products, and by implication decisions made in the design process, can extend far beyond the immediate product use. For example, the dishwasher, while possibly more energy efficient than hand washing per dish, has contributed to more dishes being washed more often, which also requires households to have a larger stock of cups, plates and cutlery. Taken even further, while doing the dishes before, people may now devote time to, for example, watching television. This requires electricity, plus it is a passive activity, requiring a higher indoor temperature for thermal comfort. The notion of extended effects of product design on daily life offers challenges, but also opportunities. The area of sustainable design is still young and neither these challenges nor opportunities have been explored to their potential. Aiming to address these, this PhD research has drawn on a particular group of theories from sociology to further explore the relation between design and changes in household resource consumption.

Sociology is a discipline that has long pondered questions regarding issues of a societal scale. Recently, a particular form of social theory grouped as theories of practice or social practice theory is (re)gaining popularity. Practice theory – as developed by amongst others Anthony Giddens, Theodore Schatzki, Andreas Reckwitz and Pierre Bourdieu – is promising to inform sustainable design for several reasons. One, because it is already used to understand and explain issues with regard to unsustainable consumption levels (e.g. Shove 2003, Spaargaren 2003, Seyfang 2006, Randles and Warde 2006, Gram-Hanssen et al. 2008, Wilhite 2008, Røpke 2009). And two, because materiality plays a central role in certain strands of the theory it speaks directly to designers. In fact, scholars in the field have already reached out to design research through several publications. In the words of Ingram, Shove and Watson (2007), practice theory is useful to gain a better understanding of how 'designed artefacts shape and are shaped by the contexts in which they are used'.

1.3 Research questions and research approach

These outreaches have not remained unnoticed in the design community and several researchers in (sustainable) design have picked up on what has been – in a very brief introduction by Shove et al. (2007:134-135) – coined 'practice-oriented design'. From earlier work in design research on this topic, it becomes clear that practice theory is not directly applicable in product design projects. It forms a theoretical stance used to understand and explain social activity and order as they are, not a method or approach to inform or inspire decisions about what could or should be in the future. More fundamentally, ideas about design and a practice theoretic outlook on change exist

quite uncomfortably next to each other. The kind of agency assumed in the idea of 'devising courses of action to change existing situations into preferred ones', and the type of closure it implies are both rejected in practice theory. On the bright side however, theories of practice do acknowledge that to some level, artefacts shape the contexts in which they are used (Ingram et al. 2007) and that things are 'irreplaceable, constitutive elements of practice' that 'enable and constrain the specificity of a practice' (Reckwitz 2002b). Although designers are ascribed a modest role in practice-oriented design, this thesis takes the position that there is certainly a role for those who give shape to mass produced consumer goods in the ways in which practices develop, be it in more or less desirable directions. Therefore the main research question is:

> Can drawing on social practice theory lead to design approaches that are more effective in addressing the issue of high and rising levels of household resource consumption than existing approaches?

For initial exploration, this question is divided into three sub questions, which are addressed in Part I of this thesis:

- What are limitations of current approaches in sustainable design? (Chapter 2)
- What is social practice theory from a design perspective? (Chapter 3)
- What are strengths and limitations of earlier integrations of practice theory into design approaches? (Chapter 4)

These questions are used to formulate an additional set of questions that will address the main question. Running ahead on the conclusions of Part I, they are:

- What does it mean to take practices, instead of interactions as a unit of *analysis* for approaches to sustainable design? (Chapter 5)
- What does it mean to take practices, instead of interactions as a unit of *design* for approaches to sustainable design? (Chapter 6)

Because these questions are cross disciplinary, deal with preferred states, are future oriented, revolve around a complex issue and aim to develop theory for design, they pre-eminently lend themselves for a research through design approach (Zimmerman et al. 2010). Such an approach leads to empirical design outcomes and at the same time to ideas and knowledge about how to design, or what is called prescriptive design knowledge. Research through design is a form of applied research in which design projects are used as an integral part of the research process. The goal of the research is to extend disciplinary understanding of the practices of design and to enhance the knowledge designers draw on by generating contextualised knowledge in a number of empirical areas (Stappers 2007). In this research, these areas are the resource intensive, but otherwise strongly different household practices of bathing and thermal comfort.

1.4. Thesis outline

Between the introduction and conclusions, the thesis contains three main parts: (I) theoretical foundations, (II) proposed approach and (III) empirical projects Figure 1-1 graphically depicts the outline of this thesis.

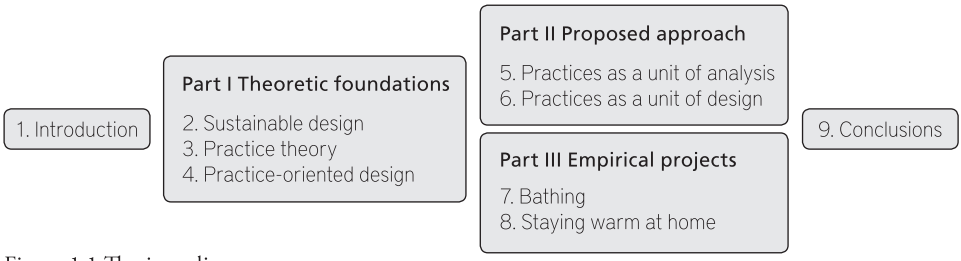

Figure 1-1 Thesis outline.

Part I, comprising Chapters 2, 3, and 4 addresses the three initial questions posed above, with the aim to explore and specify the main research question. Chapter 2 analyses sustainable design literature with the aim to identify possible reasons for the insufficient effects on levels of household resource consumption so far. Chapter 3 draws on literature on social practice theory to compose an interpretation of theories of practice specifically tailored for integration into design approaches. Chapter 4, eventually, analyses a range of publications in design research that have worked with theories of practice before, in order to get an overview of the current state of affairs in this area of research and in particular strengths and limitations of earlier attempts to develop practice-oriented design approaches.

Part II, consisting of the Chapters 5 and 6, presents the main results of the research and consists of an explanation of the proposed practice-oriented design approach. The approach is divided into a model for taking practices as a unit of analysis (Chapter 5) and a model for taking practices as a unit of design (Chapter 6). Methods for analysis aim to gain understanding of existing practices in order to inform and inspire design and find opportunities for change. Methods for design aim to generate possible less resource intensive reconfigurations of practices. It is important to explain that the order of presenting the proposed approach before the empirical projects is not chronological. Rather, the recommended approach and models were developed through and emerged from reflection on the empirical projects underlying Part III.

Part III includes Chapters 7 and 8. Chapter 7 provides an overview of the projects on bathing and Chapter 8 of those on staying warm at home. For the sake of clearly illustrating the approach proposed in Part II, the empirical projects are presented in the format of the approach. However, they were in fact much messier and haphazard than their description suggests. Appendix A contains a graphic presenting the actual chronology of the bathing projects to illustrate this difference.

The thesis closes with a conclusion chapter, in which the main research question is answered and results are discussed in the light of the research approach taken. Based on these reflections, the chapter concludes with an overview of avenues of further research.