The Habitation Lab: Using a Design Approach to Foster Innovation for Sustainable Living

Paula Femenías and Pernilla Hagbert

> *"We shape our buildings; thereafter they shape us."*
>
> Sir Winston Churchill (1874–1965)
> Prime Minister of the United Kingdom

This article describes a first step towards a strategy for using living labs as a means to foster innovation and develop new concepts of sustainable living from an architectural point of view. The overall aim is to enable truly sustainable living through radically reduced energy and resource use thus addressing both environmental and social aspects of sustainability. Earlier research has shown that contemporary housing developments, including those with a sustainable profile, do not profoundly question modern lifestyles and consumption, which is a necessity to overcome limitations of a technological focus on environmental efficiency in construction. Thus, we see an opportunity for the discipline of architecture to engage in current investments in living lab facilities in order to push innovation in the field of sustainable housing.

We introduce the concept of a "Habitation Lab", which will provide an arena for radical and high-risk design experimentation between users, building-sector actors, and academia, and we describe a case study of a planned Habitation Lab within a living lab facility where traditional solutions for daily living and habitation are questioned and new architectural innovations are explored and evaluated. The idea of using experimental activities in the field of housing is not new, and we argue that new investments should build on earlier experiences to avoid perpetuating misconceptions and repeating past failures. Furthermore, to ensure the dissemination and uptake of results, the design of the Habitation Lab should consider the innovation and learning trajectories of the building sector. We propose a transdisciplinary setting to provide a neutral arena for value creation and to increase the distribution of experiences.

Introduction

Sustainability and energy efficiency are areas that drive much of the building-related innovation at present. In Sweden, there has been a rapid development in low-energy construction (Femenías and Kadefors, 2011; tinyurl.com/mfx9aqz), but alternative concepts for the design and layout of dwellings and homes that enable changes in priorities and lifestyles have not been subject to the same development and still signify a more radical change of mindset (Hagbert et al., 2013; tinyurl.com/l5hgwct). Nevertheless, home-related resource use has been identified as a factor that largely contributes to the overall environmental impact of human actions, and should set living in the centre of attention for sustainable societal development. The standards and designs of dwellings are determined by norms within the sector, market surveys mapping customers' "willingness to pay", and regulations; however, these factors do not sufficiently reflect the urgency of our need to reduce energy and resource use. For instance, very little has changed regarding the standard of Swedish housing since the early post-war era. Even less effort has been made to adapt to a growing awareness of the environmental and social impact of the built environment, and the necessity to transition from the resource-intensive lifestyles perpetuated during the mid- and late 20th century.

The Habitation Lab: Using a Design Approach to Foster Innovation for Sustainable Living

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In this article, we explore the use of living labs as a means of fostering innovation and contributing to the development of new frames of reference focusing on the building sector and architectural practices. We introduce the concept of a "Habitation Lab" set up as a transdisciplinary innovation arena in which concepts relating to architecture and the use of space are questioned and explored. The aim for the Habitation Lab is to radically rethink the way we live, thus filling a gap where contemporary, market-driven innovation in housing fails to address fundamental questions for sustainable development. Drawing on the collaborative and user-centred principles of recent definitions of living labs (e.g., Bergvall-Kåreborn et al., 2009: tinyurl.com/m6kn9mu; McPhee et al., 2012: timreview.ca/article/601; Leminen and Westerlund, 2012: tinyurl.com/orlnfh5), the Habitation Lab is an innovation platform that emphasizes co-creation and learning between end users, partners in the building industry and related areas, academia (e.g., researchers and students from architecture and other disciplines), and, by extension, governmental bodies (e.g., planning officials and policy makers). The long-term aim is to achieve viable change by supporting innovation and learning among participants, both on professional and personal levels.

In order to induce change, the Habitation Lab has to relate to the context of development as well as change processes in the building sector. Furthermore, we should build on earlier knowledge of innovation in housing and construction when setting up experiments in the lab in order avoid “re-inventing the wheel”, perpetuating misconceptions, or repeating past failures. Consequently, in this article, we review earlier experimental activities related to housing in Sweden and briefly describe the main factors relating to innovation in construction. Next, we describe a design approach to living labs for habitation and present a case study of a Habitation Lab within a planned, purpose-built living lab, in the form of a design studio for architectural exploration. We next describe a plan for defining the types of exploration and experimentation that will be carried out in the Habitation Lab. Finally, we offer conclusions and describe the next steps for our research and for collaborations within a broader setting of a living lab.

Earlier Experiences from Building Experiments in Sweden

Knowledge in architectural design and construction is based on practical experiences built up in a slow process and throughout history. The introduction of new concepts, products, systems, or processes, responding to changing technical, market, or societal conditions, has often been approached by experimentation in order to speed up innovation and learning.

Conducting explicit experiments is not new to the industry. Bröchner and Månsson (1997; tinyurl.com/m5ucyty) report on what may be the first governmentally granted experiment with a tiled stove, which was found to halve the use of wood in Stockholm castle during the winter of 1766. Since the last century, targeted funding has been given to full-scale building experiments driven by specific challenges of the time. In the aftermaths of the 1970s oil crises, experiments and demonstrations were conducted with the aim of finding solutions that reduce energy use and oil dependence. Another main area for post-war experimentation has been industrialized production in construction. During the 1980s, participatory design was one track for development, together with "ecological" housing, which emerged in the 1970s. In recent decades, experiments and demonstrations have focused on technology development, increased productivity, and sustainable building.

Furthermore, housing research and development held an important part in building the Swedish welfare state since the early 20th century, thereby contributing to high-quality housing. Generous loans were granted for house construction, linked to definitions of "good housing" (e.g., Engfors et al., 2000; tinyurl.com/klmvzso). Based on meticulous empirical studies of people (mostly women) in action in laboratory environments, requirements regarding factors such as minimum spatial demand in relation to functionality, sunlight, or indoor climate, were developed in collaboration between academia and governmental bodies, and transferred to formal building regulations in the 1970s. In the 1990s, these somewhat restrictive regulations (not least for short-term cost efficiency) were replaced by general recommendations for functions in a dwelling. This shift coincided with a larger reorganization in which the government lifted their responsibility for funding housing and left further development to the market, the outcome of which remains a topic of debate (e.g., see Turner et al. [2002; tinyurl.com/lengj25] for an early evaluation).

Contemporary Housing Development

At present, there exist no Swedish governmental funds or grants of loans for real-world housing experiments, or building experiments in general. And, there were never any large programme funds available for experi-

The Habitation Lab: Using a Design Approach to Foster Innovation for Sustainable Living

Paula Femenías and Pernilla Hagbert

mental housing in Sweden, as was the case for example in France (Plan Urbanisme Construction Architecture, 2012; tinyurl.com/q8lk4rq) or in the Netherlands (SEV Housing Experiments Steering Group; tinyurl.com/o5uerma). Marginal qualitative experiments in housing continue to be developed by engaged and committed architects and clients. One example that is of interest for the Habitation Lab we plan is an experiment in affordable student housing called BoKompakt with a space of only 8.8 m^2 (less than 95 ft^2), which has received considerable attention (e.g., Fastighets Tidningen, 2012; tinyurl.com/kptltkk), although local planning authorities have contested further implementation. There is also new interest in co-housing as a means to address the increasing number of single households; Next Step Living in Gothenburg (nextstepliving.se/hem/) is one example.

Our recent observations of front-line sustainable housing developments indicate a strong market perspective, built on preconceptions among building professionals, which fails to deliver holistically adequate infrastructures to enable true sustainable living and dwelling (Hagbert et al., 2013; tinyurl.com/l5hgwct). There is a unilateral focus on efficiency and belief in technology as the ultimate solution to sustainable built environments, which overlooks possibilities for resident engagement. In addition, contemporary architects experience limited possibilities to engage in housing development on a more holistic level (Femenias et al., 2013; tinyurl.com/jw9rekb). The architects also seem to lack knowledge in issues regarding sustainability and do not benefit from a disciplinary debate in the field or significantly contribute to developing new practices for more radical explorations.

Innovation in Construction

The building sector has long been a focus for widespread critique regarding its perceived low level of innovation and failure to progress and change (e.g., Egan, 1998; tinyurl.com/62ad7a). It could, however, be argued that the building industry is not backwards per se, but different, and that comparisons with other industries are misplaced due to endogenous specificities of construction such as custom-order activity, complexity of production, high risk and costs, and a highly fragmented industry. (For an overview of these factors, see Nam and Tatum [1989; tinyurl.com/jvoyddv]). The interference of many factors of different character, such as site specificities, the assembly of multiple components and materials, production variation, and user behaviour, makes every building project rather unique and almost an experiment in its own right.

The use of single demonstrations or "best practice" as a method for change in construction has been criticized (e.g., Bresnen et al., 2005: tinyurl.com/keuhk6p; Fernie et al., 2006: tinyurl.com/nwjkahb). Although single experiments and demonstration projects have shown good results, they have had little influence on normal building practices, and experimental activities have been attributed a negative image in the industry (Femenías, 2004; demonstration-projects.com). Still, incremental changes in production and technology use have been the result of earlier experimentation, and the industrialization of production must be considered successful even though progress was slower than in other industrial sectors (Bougrain et al., 2010; tinyurl.com/kdgzh79). In recent years, Sweden has seen rapid development of low-energy construction that is driven by policies for energy use and cost savings but that is also mainly attributed to the systematic use of well-planned demonstration projects (Femenías and Kadefors, 2011; tinyurl.com/mfx9aqz).

There are several interlinked factors inhibiting change and learning relating to socially constructed features of the industry. As in many project-based industries, innovation in construction is mainly carried out in temporary projects and is often driven by individual champions (Nam and Tatum, 1989; tinyurl.com/jvoyddv). The practices and powers are widely distributed and localized, and the links between temporary project activities and more long-term and continuous management of the organizations involved tend to be weak (Bresnen et al., 2005; tinyurl.com/keuhk6p). In addition, a general lack of systematic monitoring and evaluation sets limits for continuous learning from project experiences (Femenías, 2004; demonstration-projects.com). Information dissemination and retrieval in the construction industry is strongly linked to individuals and their networks, using face-to-face communication (Styhre et al., 2006; tinyurl.com/kkl5jzt). This dependency on individuals and their networks further inhibits the broader implementation and diffusion of project-based experiences (Buijs and Silvester, 1996; tinyurl.com/ndyzump).

Femenias and Edén (2009; tinyurl.com/melvwrh) have defined a number of success factors for development projects in terms of hypotheses that are currently being researched. Some of the most critical factors include engaging top-level management and developing routines for evaluation, learning, and implementation of results.

The Habitation Lab: Using a Design Approach to Foster Innovation for Sustainable Living

Paula Femenías and Pernilla Hagbert

Organizations with better learning routines are more likely to both achieve and benefit from successful collaborations as they absorb and apply knowledge, including knowledge that is generated by others (Hartmann et al., 2010; tinyurl.com/kxtuyg4).

A Design Approach to Living Labs

With respect to the long knowledge-creation cycles in the building sector, the risk adversity to large-scale failure by industry, and limited governmental funding for housing innovation, among other factors, we see several motives for using experimentation in living labs to develop sustainable housing and challenge contemporary norms for living. We introduce the concept of a Habitation Lab, which was first defined by Professor Maria Nyström at Chalmers University of Technology as a living lab facility for the specific purpose of carrying out architectural and spatial experiments. A Habitation Lab could fulfil the need for arenas in which to conduct more radical experimentation and could lead to further innovation and development for sustainable housing. By actively involving the users, a Habitation Lab could potentially bridge the "rebound gap" between efficient technological structures and user behaviour to reach goals for sustainability; this value of living labs was also identified by Liedtke and colleagues (2011; tinyurl.com/9xv7gk6).

A Habitation Lab is defined as a high-fidelity lab permitting testing and development in real-time, focusing on the interface between "concepts of space use", residential functions and activities, and the users as residents and co-creators. A Habitation Lab will provide full-scale explorations, limited in space and time, which allow for high rates of experimentation and novelty. A Habitation Lab can be purposed built or installed in a real-world context, for example in existing housing.

In order to fully engage in and benefit from innovation in the living lab, the experimentation has to be well-planned, not least regarding monitoring and evaluation, and the engaged industry partners should establish learning routines to benefit from results. The lab setting has the advantage of providing a controlled environment to enable a more rigorous scientific investigation, yet simultaneously acknowledging the limitations to mimic real-world settings. In recent decades, virtual labs have been developed as a means to diminish risk in full-scale settings and enabling rapid digital prototyping. However, from a behavioural perspective, a limitation of virtual labs is that those results have been found difficult to replicate in real life.

To enable a networked innovation arena based on value creation for all involved parties (Ståhlbröst, 2012; tinyurl.com/l8ur4cu), we favour a neutral, transdisciplinary setting for a Habitation Lab. By applying the categories defined by Leminen, Westerlund, and Nyström (2012; timreview.ca/article/602), this setting can be seen as a hybrid between a provider-driven (i.e., academia-driven) living lab and a utilizer-driven (i.e., industry driven) living lab). Thus, users are important co-creators, but not drivers, and public-sector actors (e.g., planning authorities, non-governmental actors in the field of housing) are invited for observations and discussions. The transdisciplinary setting calls for openness and flexibility among participants; it adapts to the context of application and in turn allows for changes, enabling new participants to enter and new ideas to emerge over time (e.g., Gibbons et al., 1994; tinyurl.com/kqqdutk). We consider transdisciplinary approaches to be an ideal alternative to disciplinary research (which has more limited diffusion) for solving complex real-world problems in the field of sustainability.

What we aim for is a question-driven innovation arena where resource efficiency and human living functions are in the centre. The sharing of expertise and risk in collaboration between academia, industry, and users should increase the willingness to participate. The transdisciplinary configuration should contribute to increased openness, perceived ownership, reliability, and trust in outcomes and thus by extension, the implementation, uptake, and effect of results. The objective is to engage users, researchers, and industry partners in the co-creation of knowledge, strategies, products, and services. We aim for mutual understanding among all participants, based on personal insights and a discussion on changing home-based practices, which in turn are argued to have influence on professional practices.

By bringing together various disciplinary expertise, precedents such as the PlaceLab at the Massachusetts Institute of Technology (tinyurl.com/vggfq), have addressed the need to test new technologies and designs in environments providing “everyday” settings. Whereas the PlaceLab focuses primarily on observations of users and their interaction patterns with new home environments, the planned Habitation Lab focuses on the co-design of innovative solutions for space use with end users as well as their appropriation of these solutions. A more applicable reference is the 2005 Norwegian design experiment, TreStykke, which allowed users to create “a home” within a very limited space shared by other inhabitants (Thomsen and Tjora, 2006; tinyurl.com/l3oxerb). A Swedish experiment in the post-

The Habitation Lab: Using a Design Approach to Foster Innovation for Sustainable Living

Paula Femenías and Pernilla Hagbert

war suburban area of Tensta, where apartments were redesigned to raise the attractiveness of the area and the fit to the needs of contemporary users (Stenberg, 2012; tinyurl.com/ml323vz), shows the possibility of locating Habitation Lab ideas in a real-life context. Further inspiration can be drawn from Vision Live Elderly (tinyurl.com/mgs246m), a testbed and exhibition centre in Gothenburg, which provided development and innovation in housing facilities for the elderly.

Case Study: A Habitation Lab within the HSB Living Lab

The case study outlined here is based on work by a team of architectural researchers from the Department of Architecture at Chalmers University of Technology (chalmers.se) and the School of Design and Crafts (hdk.gu.se) in Gothenburg Sweden, and the College of Architecture at the University of Houston (arch.uh.edu) in the United States. The team also benefits from the participation of an architect from National Aeronautics and Space Administration (NASA; nasa.gov), and the extensive experience of researchers who have studied the effects of living under extreme resource limitations. The team is part of an inter-disciplinary research environment called Homes for Tomorrow (h42; homesfor tomorrow.se), which is located within Chalmers University of Technology. Homes for Tomorrow consists primarily of architects, engineers, and psychologists, and industrial design engineers further enrich this environment through collaborations.

A living lab facility, called the HSB Living Lab (hsb.se/goteborg/hsb-living-lab) is currently under development in relation to this inter-disciplinary research environment on one of the campuses of Chalmers University of Technology. The HSB Living Lab is linked to the SusLabNWE programme (Suslab; suslabnwe.eu), which supports the development of user-centred design research methodologies and sensor technology in several European countries. The lab is also supported by the Climate-KIC (www.climate-kic.org), Europe's largest public-private innovation partnership focused on climate change. The HSB Living Lab will be set up in collaboration with i) HSB, a cooperatively owned private housing developer, ii) Tengbom (tengbom.se), a nationally operating architectural consultant), and iii) representatives from different disciplines and organizations at Chalmers University of Technology and the Johannebergs Science Park (johannebergsciencepark.com), which bring together industry and science. The transdisciplinary setting is illustrated in Figure 1.

The plan for the HSB Living Lab facility is to provide both student accommodations and research facilities. We propose to install a Habitation Lab within this facil-

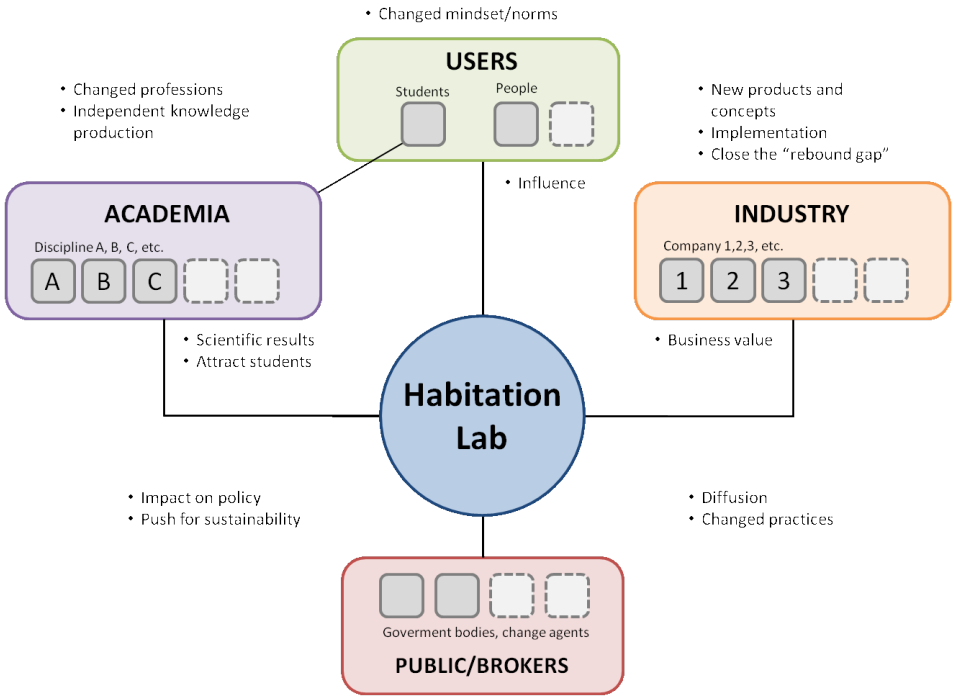

Figure 1. The transdisciplinary setting of the Habitation Lab, indicating possible generated value for different actors as well as diffusion and outcomes

The Habitation Lab: Using a Design Approach to Foster Innovation for Sustainable Living

Paula Femenías and Pernilla Hagbert

ity in the form of a design studio for research and educational purposes, in order to push for long-term change among future building professionals. Researchers and students in architecture as well as from other disciplines would participate in research and innovation in the Habitation Lab. The role of the researchers is to define the settings for experiments in which students will participate, and to observe, document, monitor, and evaluate results. For example, the design studio can take the form of a design–build–live experience, in which students accordingly have the role as designers and users, and if possible participate in the production of the "home" environment. The studio could feature game-like settings with resource-use targets that are defined by the researchers.

In planning the Habitation Lab, we have to prepare to meet several challenges. An iterative process must be developed, including continued reflection of the methodology based on recurrent evaluations and re-definitions. Other challenges with the Habitation Lab include the reproduction of real-life situations, ethical use of data, legal rights to results, and the challenge to sustain the lab over time, both financially and administratively. Furthermore, the effectiveness of isolated interventions that are not properly anchored should be avoided, further pointing towards the need for an integrative approach. More importantly, there is a paradox in the basic assumptions of a living lab: to create value for all involved. The sustainability agenda and the user-driven agenda might challenge the fundamental elements of the industry partners' business strategies, which might be, for example, to provide components and materials or entire dwellings on an economic market. The Habitation Lab calls for a flexible mindset in which participants can see beyond individual and organizational needs (Leminen and Westerlund, 2012; tinyurl.com/orlnfh5).

Defining Architectural Explorations

So what type of experimentation will be carried out in the Habitation Lab? As an example of an opportunity for exploration, a Norwegian study points towards "floor space per person" as one of the most significant indicators for energy use in housing (Hille et al., 2011; tinyurl.com/mzq5boq). Consequently, in order to radically challenge contemporary housing development and limit the environmental footprint of residences, research that defines and evaluates design explorations on spatial configurations regarding hierarchy and usage would be of prime interest. Experimentation could focus on optimizing living space and increasing the use of shared facilities at the same time as fulfilling different functional demands of living and dwelling (e.g., meal preparation, rest, work, social interactions).

In order to define research in relation to spatial design, we make use of several sources:

1. User-centred insights from studies conducted with participants from the target group of residents for the HSB Living Lab and student home (e.g., surveys and interviews with students)

2. Empirical studies of living functions (e.g., use of products, resources, and space) with targeted groups of people

3. Review of earlier research and experimentation of space use related to living and dwelling (e.g., living labs, full-scale building experiments)

4. Review of experiences from experimentation for space habitation (e.g., insights from NASA) and design for extremes on earth (e.g., to provide benchmarks for continued experimentation)

Interdisciplinary collaboration is also essential. We propose design as a method to systematically visualize and link different living functions in a dwelling. In addition, design allows us to connect different interdisciplinary research projects of a living lab, which have a direct link to these functions. In effect, this means formulating a type of systemic "tree" map, where living activities are related to each other, their respective resource use, and subsequently, appropriate research clusters. Furthermore, we will explore the contribution of architectural knowledge as a mediator in interdisciplinary and transdisciplinary settings of living labs, where different disciplines and professional actors meets; the form and outcomes of such links between actors are illustrated in Figure 1. Architectural knowledge includes the ability to understand the whole picture of usage in the meeting between object, function, and perception. In combination with the systemic ability of design thinking, architectural knowledge can be used as a means to structure and interpret results of more narrow, in-depth experimentation carried out by other scientific research groups.

The Habitation Lab: Using a Design Approach to Foster Innovation for Sustainable Living

Paula Femenías and Pernilla Hagbert

Conclusion

In this article, we have outlined a strategy for a Habitation Lab as an arena to foster research, experimentation, and innovation within the discipline of architecture. We envision the Habitation Lab as a vehicle for more radical innovation that questions fundamental issues relating to the use of space and resources for living. Such efforts are required to further develop contemporary housing in order to radically reduce the environmental footprint of our dwellings, thus pushing development of sustainable housing and norms for living beyond what is produced in contemporary front-line housing projects.

We have designed a case for a Habitation Lab within the planned HSB Living Lab on the campus of Chalmers University of Technology. The Habitation Lab, or parts of it, should be a design studio for educational purposes. We propose a transdisciplinary setting, where end users, building industry partners, and academia collaborate and are co-creators of ideas and innovative concepts. An important idea for the transdisciplinary innovation arena, as well as motive behind the involvement of education in the Habitation Lab, is to create a forum for social learning sustained by the sharing of insights on professional and personal levels among students, researchers, and participants from the industry.

Our design for a Habitation Lab has not yet been tested in practice. Continued research focuses on further specifications of partners and the transdisciplinary setting, the integration of the Habitation Lab in research and educational programmes, and the continued definition of specific parameters for architectural exploration. Once the first projects have been carried out in the Habitation Lab, the strengths and weakness of the lab setting must be evaluated to continuously enhance the outcomes. On a meta-level, it will also be important to study the influence of the Habitation Lab on innovation in mainstream building practices.

Acknowledgements

The article is part of ongoing work within a team of architects and researchers at Chalmers University of Technology. We wish to acknowledge the valuable input of Professor Maria Nyström who, in addition to coining the term "Habitation Lab", contributed to discussions about the concept by sharing her extensive experience in the fields of experimentation in homes and kitchens. We thank Larry Toups, an architect at NASA and a visiting Professor at Chalmers, for his contributions to the development of the Habitation Lab concept. We are grateful to Olga Bannova, architect and doctoral student at Chalmers and teacher at Houston University of Technology, for sharing her substantial experience in working with architectural design in extreme climates. Finally, we wish to thank the editor, the guest editors, and an anonymous reviewer for very valuable suggestions and comments to improve our article.

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Citation: Femenías, P. and P. Hagbert. 2013. The Habitation Lab: Using a Design Approach to Foster Innovation for Sustainable Living. *Technology Innovation Management Review*. November 2013: 15–21.

Keywords: innovation, living labs, Habitation Lab, experimentation, sustainable, residing, housing development