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## Understanding of Danish Passive Houses based on Pilot Project the Comfort Houses

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*Published in:*  
Design Research Epistemologies I

*Publication date:*  
2010

*Document Version*  
Publisher's PDF, also known as Version of record

[Link to publication from Aalborg University](#)

*Citation for published version (APA):*  
Brunsgaard, C. (2010). Understanding of Danish Passive Houses based on Pilot Project the Comfort Houses. In O. B. Jensen (Ed.), *Design Research Epistemologies I: research in architectural design* (pp. 61-78). Institut for Arkitektur og Medieteknologi. A&D Files

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*4. Understanding of Danish Passive Houses based on Pilot Project the Comfort Houses*

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**Timeline:** 01.08.2007 - 31.07.2010

**Keywords:** Architecture, Passive houses, Low-energy, Indoor environment, Everyday life, Design processes.

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Project/chapter	Theory input	Methodology	Epistemology
Understanding of Danish Passive Houses based on Pilot Project the Comfort Houses	Sociology (everyday life), Engineering science, passive house theory, architectural theory	Interviews, measuring/calculations, (and observations, photo documentary, survey)	Empirical-analytical Phenomenology

## *Introduction & Research question*

The building industry in Denmark and the rest of Europe is facing challenges in fulfilling the EU directive of 2002. New buildings and renovation projects need to improve the energy performance to be able to fulfil the Kyoto agreement from 1998 (Directive 2002). In Denmark it has resulted in new building codes according to energy use, which contains a classification of low energy buildings, which will be strengthened the following 5-10 years. By implementing tighter energy demands and energy labelling for existing buildings the awareness of energy performance grows and the energy performance of buildings become a competitive parameter. For the Danish building industry it means that they are facing new challenges both in developing new intelligent and holistic building concepts but also new challenges for the manufacturer of products. Today the build environment accounts for about 40 % of the energy consumption in the EU and it is continuing to expand. It is a result of an effort to give the building users an optimum indoor environment by good ventilation, comfortable temperatures and sufficient light. The level of energy consumption and the quality of the indoor environment in a specific building are very dependent on design and construction of the building envelope. Therefore to be able to fulfil the directive and to protect our environment we need to focus on new building concepts which both generate low energy consumption and a comfortable indoor climate.

In Germany they have build thousands of low energy houses they call passive houses. The concept is now very well acknowledged internationally and many countries are constructing houses that fulfil the passive house standard defined by the Passive House Institute in Darmstadt, Germany ([www.passiv.de](http://www.passiv.de)). In Denmark few certified passive houses have been built in the last 2-3 years, therefore the building industry still need to find its own approach. It is tried through the project THE COMFORT HOUSES ([www.komforthusene.dk](http://www.komforthusene.dk)).

Besides fulfilling the German passive house standard THE COMFORT HOUSES should also have a high level of indoor environmental comfort – a parameter that the initiators think appeal more to the Danish population than saving energy. The passive house solutions can not be copied directly from Germany or Austria to Denmark because the requirements from the Danish residents, the traditions in the building industry and the architectural traditions are different. Therefore it is important to find a Danish approach, to get passive houses into the Danish market and thereby minimize the energy consumption in new housing projects. Besides energy savings and new structural solutions also architecture, everyday life and the future ways of living has to be integrated if they should be future-proof and saleable in relation to the buyers and their needs. Therefore knowledge and experience about the architecture, building technique, indoor environment, user behaviour and user needs are studied to reach a more holistic approach.



Figure 1: Overview of the Comfort Houses that fulfils the German passive house standard.

The overall research question is therefore:

**What is a Danish passive house seen from the experiences of the Comfort Houses? And what can these experiences enlighten about the future production and use of passive houses?**

To answer that the following study fields are examined: *The design process, The construction process, Architectural expression and building technology, Architecture and everyday life and Indoor climate.*

All study fields will be touched upon, but the main focus will be on *The design process, Architecture and every day life and Indoor climate.* Therefore following sub-research questions arise:

- **How has the consortiums behind the Comfort Houses approached the design process according to teamwork, method and tools? And what barriers and possibilities lie within the approaches?**
- **How do the residents of the Comfort Houses experience the passive house architecture and the technique? And has their everyday life changed by moving into a passive house?**
- **How do the residents of the Comfort Houses experience the indoor environment and the adjustment of it? And how does it relate to the measured indoor environment? And in what degree do the Comfort Houses live up to a comfortable indoor environment?**

What is meant by architecture? The definition of architecture is generally the art and science to design buildings, rooms or physical structures. In architecture the practical and

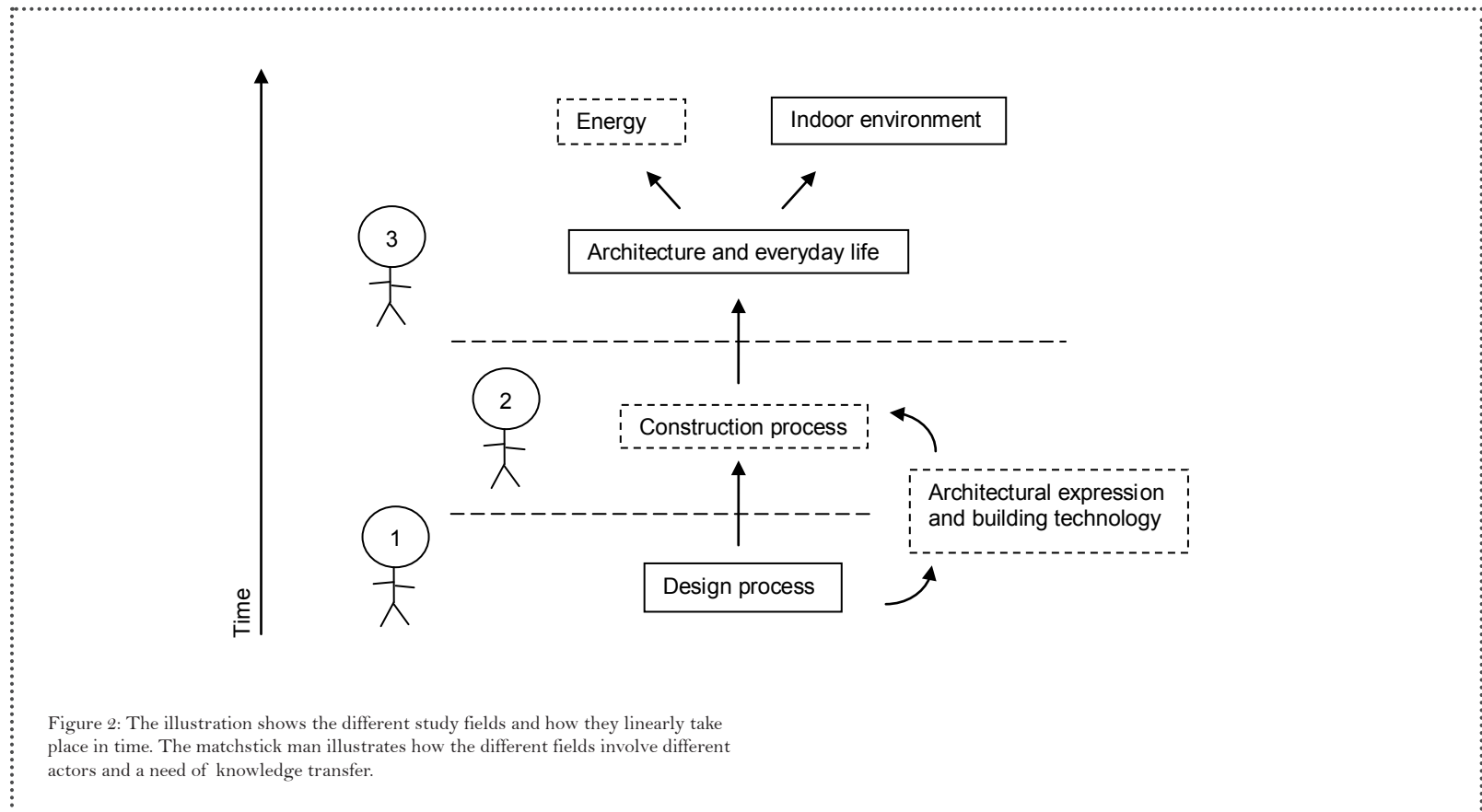
the aesthetics are inseparable e.g. functions of the house, constructions and materials, spatiality, volume, texture, light and shadow etc. Vitruvius defined before year 1500 architecture to consist of three interrelated terms: *firmitas*, *utilitas* and *venustas*, which can be translated by structural stability, appropriate spatial accommodation and attractive appearance (www.britannica.com). The purpose of this section is not to do a thorough explanation or definition of what architecture is, but just to clarify what is meant by *architecture* in this particular context. The aim of this research is to understand the everyday life as it unfolds within the architecture (or the home) – what works well in the house and what does not. And the aim is not to make an extensive architectural analysis of the houses. The Comfort Houses are investigated from the occupants' point of view, since they are the ones who live in the houses everyday and their experiences generate useful knowledge about the life that unfolds in a passive house compared to a "traditional" house. The focus will therefore, in the light of Vitruvius' terms, be on *utilitas* (or translated to appropriate spatial accommodation or functionality) and less on structural stability and beauty, as it will not make sense to investigate the occupants' understanding of the latter as their understandings are on another level than the understanding from the professionals within these fields. Generally the occupants' horizon of understanding is primarily based on functionality, usability of the house and their life within the house. The occupants are seen as representatives of the target group of this type of houses and they will represent the future occupants or owners of passive houses, therefore it is important to investigate their experience with the outcome of the Comfort House project.

Ideally all above listed study fields should be studied to get a more holistic understanding of passive houses in Denmark, but a limitation is necessary to fit the research within the timeframe (other study field could of course also be included like e.g. economy and politics etc.). Figure 2 shows how



the study fields are connected and has an influence on each other. For example first the design process defines what to build and how to build in the construction process. Then the residents move into the houses and create an everyday life. Then as a result the house has an energy use and an indoor environment. It is still believed that it is possible to enlighten how to approach passive houses in Denmark in a holistic way (meaning both focusing on architecture, energy demands

and indoor environment of the building so it 'fits together' in a whole) in the future by giving some of the study fields less focus. It is still possible to understand the connection between the design decisions made in the design process and the experience of the architecture and everyday life of the residents without an in-depth analysis of the construction process.



## Methods

The project is based on a case study design. The project consists of ten cases which are THE COMFORT HOUSES and the actors connected to them. The actors are the consortiums that have designed the houses, the craftsmen and the resident in the houses. To be able to achieve a holistic understanding as described above each case will contain more study fields; therefore it can be defined as an *embedded multiple-case* design (Yin 1995).

The first step is to examine each study field in each case and conclude upon them. Then a comparative study of the study fields is made across all cases. Furthermore a comparative study is done across research fields if possible, illustrated in figure 3. In the comparative studies there will be searched for patterns, consistency, new potentials and any dependency between the research fields to be able to develop a holistic understanding of passive houses in Denmark. In each study field different methods is used, both quantitative and qualitative. The quantitative methods are e.g. measurements of the energy use and indoor environment, questionnaires and calculations and simulations of building details. The qualitative methods are e.g. interviews, observations and photo documentation. The methodical approach of this research can be called *mixed methods* (Bryman 2008).



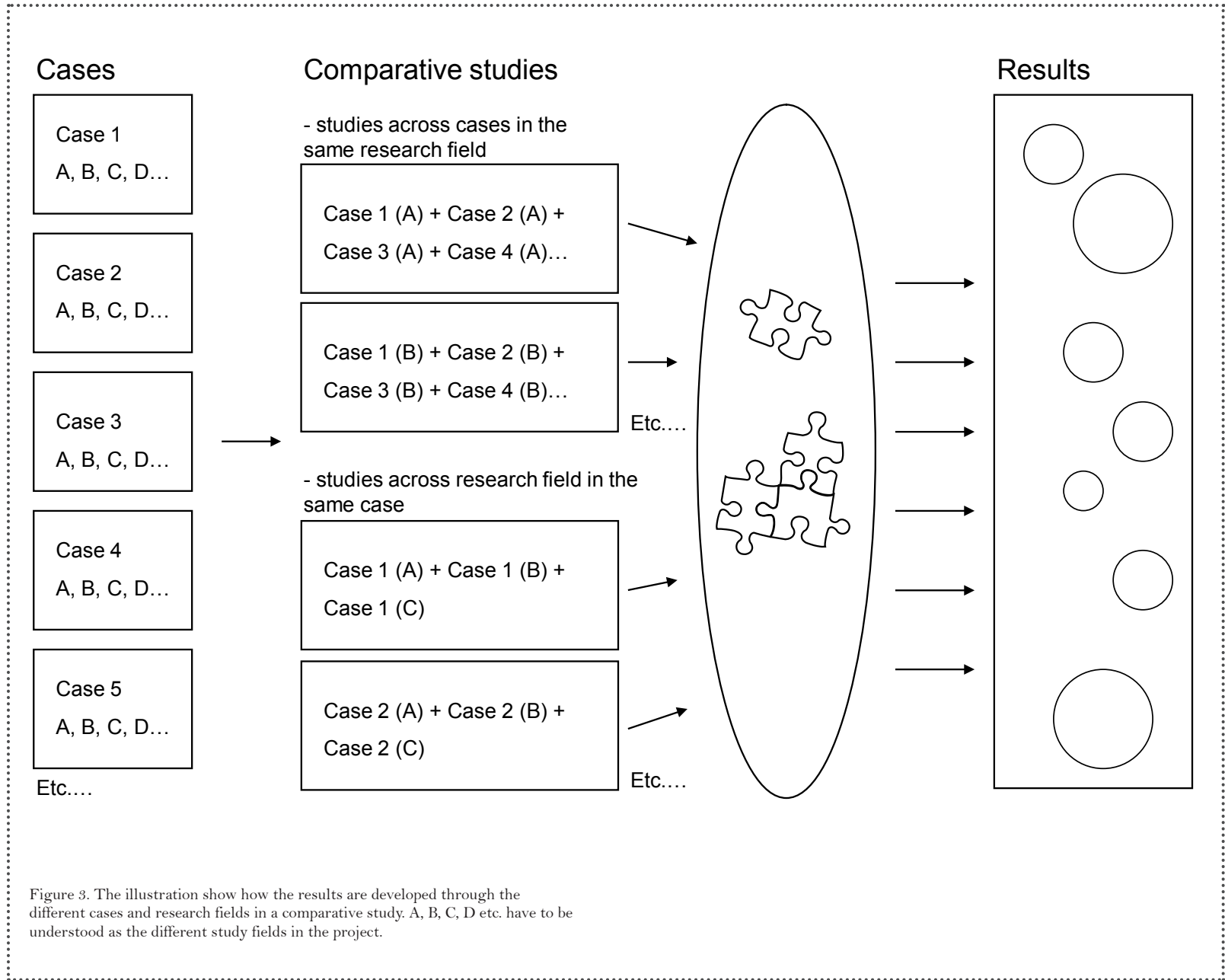


Figure 3. The illustration show how the results are developed through the different cases and research fields in a comparative study. A, B, C, D etc. have to be understood as the different study fields in the project.

### *Mixed method*

Previous some researchers argued that it was not possible to combine qualitative and quantitative methods because a) the embedded methods are not feasible or even desirable. They argue that the two research strategies provide different procedures and therefore different epistemological implications. b) The other argument is that qualitative and quantitative research belong to each there paradigm and according to Kuhn, paradigms are incommensurable. Since the 80's the argument for combining research has increased. There are areas of overlap and shared aims between qualitative and quantitative research and the paradigmatic war is almost over (Bryman 2008). Looking at e.g. the field of architecture in practice, which works with aesthetic as one of the main aspects, also works with aspects from other professions like engineering, sociology, psychology, politics and more. Some of these professions belong to different paradigms but can easily be combined - or ells architecture would not make sense. Therefore I believe it is necessary in many cases to work with mixed methods, both when you design architecture in practice and when you do research about architecture.

There are different ways in which mixed methods have been carried out, and can be categorised under different terms e.g. *triangulation, completeness, process, different research questions, explanation, illustration, diversity of view etc.* (Bryman 2008). The mixed method in this project can be categorised as *completeness, different research questions and diversity of views* according to the categories in Social Research Methods by Alan Bryman. *Completeness and different research questions* are about using different methods – qualitative and quantitative, because some methods do not provide you with all you need to know or the answers to your research questions, then you have to use more methods to get a more comprehensive view of the research field. These two approaches cover the overall approach of the PhD project, where *Diversity of view* is used as an approach in some of the study fields within the thesis to

be cross-disciplinary between engineering and architecture. An example is an investigation of the optimal solutions for how a window is build into a passive house according to the linear thermal transmittance and to the architectural expression of the solution (Brunsgaard 2008). By looking at the research with *Diversity of view* it shows that the best technical solutions is not necessary the best architectural solution. To evaluate different solutions presented in this research you need to switch between quantitative simulations and qualitative subjective experiences of architectural expressions.

## Theoretical frame

Overall this PhD. thesis takes off in the passive house standard of the Darmstadt Institute in Germany. This is not a profound theory but the standard is based on international norms and standards which original is based on theories developed from empirical experiments and analysis within natural science. The passive house standard is developed and refined from the late 80's and consists today of three criteria listed in table 1.

Tabel 1. The passive house criteria (www.passive.de)

Space heat demand	max. 15 kWh/m <sup>2</sup> per year (net m <sup>2</sup> )
Primary energy demand	max. 120 kWh/m <sup>2</sup> per year (net m <sup>2</sup> incl. household)
Air tightness	max. 0,6 h <sup>-1</sup> at pressure difference of +/- 50 Pa

The standard also includes a calculation method which is different from other energy calculation methods. This calculations method has to be used to document if a building project fulfils the criteria of a passive house or not. It is also called the passive house *concept*. The passive house concept states that by fulfilling the three criteria you save the most energy in the building during operation, which makes the concept into a kind of theory to save energy in new buildings. Besides the standard the concepts have some recommendation according to the building design and the

technical installations which can be found on the webpage of the Passive House Institute ([www.passive.de](http://www.passive.de)).

Because of the wide approach in the project it is also necessary to approach the project wide theoretically as well. It means that the theoretical frame changes according to specific research field. In the following I have listed theories that the main study fields draw upon.

## The design process

To be able to understand the different design processes behind the ten cases, an insight in different theories in approaching the design process is necessary. Here I have looked at how a traditional design process generally works in practise and different Integrated Design Processes (Brunsgaard 2008). The most central theories are the integrated design process developed by IEA Task 23 Subtask B - Optimisation of Solar Energy Use in Large Buildings – Integrated Design Process Guideline (Löhnert 2003) and as a result of that Mary-Ann

Knudstrup, Architecture & Design at Aalborg University developed a the Integrated Design Processes for problem based learning (Knudstrup 2004). The theory of integrated design states that by working integrated or cross-disciplinary by combining architecture, design, functional aspects, energy consumption, indoor environment, technology, and construction, you eliminate mistakes and bad performing buildings and you end up with a more holistic building design (Löhnert 2003).

### Architecture and everyday life

In the analysis of how the passive house architecture influences the resident's *everyday life I use the theories of everyday life and life-modes* (The Danish word "livsform" is translated in Michael Hviid Jacobsen "Encountering the Everyday – an Introduction to the Sociologies of the Unnoticed" to *life-modes*, but others use the word *life-forms* - his paper will use the first). Alfred Schutz (Schutz 2005) and Birte Bech-Jørgensen (Bech-Jørgensen 1997 and 2002) work with the concept of *common sense* which describes a kind of natural attitude which can describe the life - how it seems given and natural. Birthe Bech-Jørgensen states that by using a double perspective you get an understanding of people's everyday life. The everyday life has to be observed from the *conditions* of a certain everyday life (perspective 1) and how the people *manage* the everyday activities (perspective 2), illustrated in figure 4. Birthe Bech-Jørgensen's research is about the meeting between people, but in this research it is more about the meeting between people and the architecture and its technique. Therefore I believe that the architectural design solutions can have an influencing on our behavior in our everyday life. Therefore, besides the demographics, the architecture is a part of the *conditions* to understand the everyday life. Lone Rahbek Christensen has defined three different life-modes of how people relate to their work and free time – *the self-employed, the wage earners and the career professionals* (Christensen 1994). This theory is included because it offers an alternative perspective and useful tool to

categorise lifestyle or everyday life according to the relation between work, family and spare time. The idea is not to use this theory equally to the theories of everyday life, but I will borrow elements that can be useful to understand the everyday life of the residents (I will get back to why it should not stand alone as a theory). The life-modes are seen as a part of the double perspective by Bech-Jørgensen - the *conditions*, to understand people's everyday life in the home, because that contains the family and spare time and sometimes also the work, which the life-modes tell us something about. Some think the theory behind life modes is too ridged, but the idea is not to place people in one category, but it is a theoretical analytical tool and is not found in reality in the society. The theory is also criticised for not taking modernised families into account e.g. dual-career, single parents and division of labour in the home (Jacobsen 2009). This critique will of course be taken into account when labelling the families.

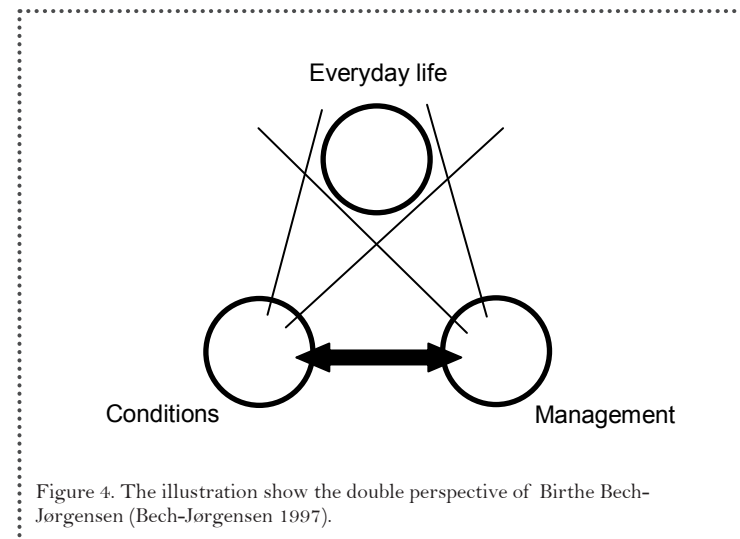


Figure 4. The illustration show the double perspective of Birthe Bech-Jørgensen (Bech-Jørgensen 1997).

### *The indoor environment and The building technology*

Danish and international standards are used to document the indoor environment or to investigate different building details of the houses e.g. CR 1752 (DS/CEN/CR 1752 2001).

The above theories belong to different scientific traditions which will be discussed in the following section

### *Epistemology*

As mentioned above different methods and theories are used in the process of collecting knowledge and experiences from THE COMFORT HOUSES because architecture can be divided into two parts; the measurable and the immeasurable. It means the project both takes qualitative approaches based on subjective sources of information, and quantitative approaches based on objective sources of information. Scientifically these two approaches are founded on two lines in the scientific field: natural science and social science.

#### *Different scientific positions*

Natural science is based in the empirical analytical scientific approach and has been dominating since the 1920'ies. At that time there were a clear distinction between objective and factual knowledge on one side and the subjective norms and values on the other side. The clear distinction was later doubted and resulted in different kinds of empirical analytical approaches, but generally empirical analytical scientists are focused on what is positively given and sticks to the verified sayings and refrain from emotions and opinions. The development in the empirical analytical approach today is not so much to set up specific normative instructions for how research should be done, but more to achieve an image of what research is as correct as possible (Andersen 1994). But what is empirical analytical science?

In the empirical analytical field is the object taken out of its natural environment and idealised – it becomes an artefact. It means you will leave out elements which is not relevant to the “experiment”. Yet there can still be different ways to outline or define boundaries for an object, not of empirical character but founded in the ontological assumptions. An experiment presupposes a theoretical frame for it to be interpreted and often the ontology lies implicit within it. *Generalisation based on empirical findings* (specific level) or *principals* (general level) can be understood as theories and becomes preconditions for the scientific work. (Kragh 1991)

Social science on the other hand is often more subject orientated and often uses qualitative methods because they are good to discover new fields of knowledge and can tell something about people's motives of actions. In this field we find among many others the phenomenological and the hermeneutical approach. (In the following the discussions will limit to these two approaches of social science, because the goal with this publication is not to describe all scientific approaches). When working with qualitative methods it is important to be aware of what scientific field you place yourself in, because they have different ideas of how the human acts, it differs what part the scientist plays and you need different qualitative methods and analysis which also produce different kind of knowledge (Jacobsen 2008).

The phenomenological and hermeneutic approaches both have similarities and differences. They both take off in the individual. An individual that can think, feel and act independently, which thereby influence the social life. These approaches also have in common that they concern about *why* people do, think or act as they do and not just *what* they do. The phenomenological and hermeneutical approaches differ by the way knowledge is understood. It will be described shortly in the following. In hermeneutic you want to understand the part in connection to the whole, meaning that the data have to be understood in connection to the context

it is produced in. The data do not speak for it self; it has to be interpreted in its context to make sense. Therefore the researcher itself and his/hers pre-understanding becomes an important part of the findings. In phenomenology the phenomenon is studied on the basis of how the individuals experience reality. The phenomenon does not need to be interpreted but can be described and understood out of how the individual experience them. Therefore the researcher need to step back and be an objective observer and his/hers opinion should not be put in action (Jacobsen 2008).

### *Scientific position(s) in this Ph.D. thesis*

The study fields of this Ph.D. can not be positioned in one scientific position, because they are founded in theories that are based in different scientific positions – eclecticism. In the following the scientific position of each study field will be described and discussed.

The theories behind the passive house standard are based in the empirical analytical field as it is founded in *generalisations based on empirical findings and principals* related to scientific work of indoor environmental and energy engineering. These *principals* is enlighten through national and international standards. That way different “experiments” or in this case calculations of buildings energy use can be produced or reproduced and be compared.

The study of the *architecture and everyday* life wants to find out how the residents experience the architecture of the passive house and want to know if these types of houses affect the everyday life in the house, and in that case how it affects it. A hermeneutic approach would contain an interpretation of the statement (the part) in relation to the context (the whole) to be able to generate insight. An example could be that a resident thinks he feels too exposed in the house because of the big windows to the south. To be able to understand why he feels too exposed we need to understand the context. The context could be several e.g. the culture, the society, the

background or even the childhood of the resident and more. Additionally the researcher has to take his or hers own pre-understanding into account. In a hermeneutic approach there is not one truth or result, it is more a process where more and more interpretations will cover the field better and better (Jacobsen 2008). The outcome of a statement often leads to more comprehensive description than the original statement (Kvale 1997). In the phenomenological approach on the other hand it is interesting to find out how the phenomenon appear and manifest itself based on how people experience them. Often architecture and the life inside is something you sense and experience and the phenomenological approach will produce knowledge that describes that experience as unprejudiced as possible. Alfred Schutz created with a conceptual universe a phenomenological foundation for how to use everyday life as a basis of the analysis of the social life. The actions that people (or the residents in this case) do in their everyday life on the basis of their consciousness of the everyday life are full of information about how the social life functions and are appointed. Alfred Schutz work with the term inter-subjectivity which is what is common and general for various individuals (Jacobsen 2008). The results are often a condensation of the original statement which still makes sense for the people in their everyday life based on their opinion about their actions (Kvale 1997). Therefore a scientific position in phenomenology would in this study field about the *architecture and everyday life* create knowledge that can be used and understood by other individuals than the ones involved. In this study field the theory about life modes is also involved as mentioned earlier. Life modes are different from the phenomenological inspired everyday life analysis. The life modes were developed by Lone Rahbek Christensen together with Thomas Højrup and were theoretically inspired by structural Marxism and dialectics. The reason is that the research had a different take-off. Thomas Højrup started off by studying the regional planning and legislation and wanted to develop a method to understand the conflicts in the living conditions of different social groups (Jacobsen 2009).



This offset in social formation is far away from the aim of this thesis; therefore should the theory not be a big part of the theoretical foundation. But as explained earlier, the life modes say something about the family life and the spare time in relation to work – and this relation also has an influence on how they use and live in the house. Therefore I only take element of this theory – the characteristics of the different life modes, and join them with the everyday life theory as described earlier. It means that I will not theoretically touch upon Marxism and dialectic.

By studying the design processes you should at least be aware of what scientific position you, as a researcher, have to the research field, but it is also worth to be aware of what scientific field the artefact you study moves around in.

Let us start to look at the scientific field of the artefact. Two design processes will never be the same and sometimes they actually need to be different – it depends on the project. Each project has individual goals and demand and different design teams have different experiences and knowledge. It means that the theoretical understanding of the design processes do not necessarily take-off in the same theoretical position or balance between theories (knowing that rarely a design

process is looked upon theoretically in practice). Looking at the theory behind the integrated design process, it wants to combine both technical and architectural aspect at the same time in the process. The balance between the fields will as mentioned before vary according to the scope of the project – a factory and a dwelling will generally not aim at the same architectural or technical level, but still both fields are in play at the same time. If we look at the traditional design processes, which is a more linear process (Brunsgaard 2009), each scientific understanding takes care of each their field. It means that the design process is looked upon by one set of “glasses” at a time. The scientific approach in the integrated design process is therefore to constantly switch between the empirical analytical and the phenomenological “glasses”.

The scientific position I, as a researcher, has to this study field, is to stand on the side and study the artefact – the design process and the constellation of the teamwork. It results in findings of where the different artefacts are positioned according to the different theories of design processes. The results will be unprejudiced descriptions as possible of how the design team experiences the phenomenon – the design process. The scientific position in the research of the design process is phenomenological.

Tabel 2: The theory input, methodology and epistemology of the different study fields in focus in the thesis.

Study fields in focus	Theory input	Methodology	Epistemology
The design process	The traditional and integrated design processes	Interviews	Phenomenological
Architecture and everyday Life	Everyday life theories (Life-modes)	Interviews	Phenomenological
Indoor environment	International standards	Measuring/calculations Interviews	Empirical analytical Phenomenological

The study field about the indoor environment and building technique is originally founded in the empirical analytical field, but we see a bigger and bigger interest in viewing the fields of energy and indoor environment more widely. An example is the PhD thesis of Charlotta Isaksson “*Sustainable learning about indoor heating? – Domesticating energy technology in passive houses*” (Isaksson 2009), which has a sociological approach. She is interested in understanding how the tenants experience and learn to live with energy related technology as a part of their everyday practises. In my thesis I both ask the resident about their experiences and opinions, but also measured the indoor environment. The qualitative and quantitative results are analysed in a comparative study. It is therefore again necessary to use two set of “glasses” – the empirical analytical and the phenomenological.

### *A thought experiment*

Would it make sense and what kind of knowledge would the thesis generate if only one perspective was taken e.g. the empirical analytical? If all research fields were to be looked upon with the same scientific approach, the knowledge produced would without any doubt be different. In the following I will try to make a thought experiment to clarify what will change within the thesis by looking at the three research fields in focus; *the design process, architecture and everyday life and the indoor environment.*

Let us start with the area of indoor environment were the empirical analytical approach already is in play. The standard of indoor environment forms the basis of the work e.g. CR

1752 (DS/CEN/CR 1752 2001). The outcome tells us *how* the indoor environment is. E.g. 75% of the time the house has temperatures between 20 and 22 °C and the last 25% it is below 20 °C. The situation is seen as an isolated object, an artefact, as described earlier. Can the standard give us the answers to why the temperatures are lower in 25% of the time? Maybe if we for example can observe that the window has been open. But the standard cannot tell *why* the window has been open. The researchers can have some ideas, but they are based on his/hers previous experiences and not based on empirical scientific work. If the researcher needs to know *why*, he/she has to step out of the observable “experiment” and involve e.g. the occupants, but then the epistemological approach is changing.

To imagine an empirical analytical approach to the research of the design processes can be difficult, because the approaches of social science has become such an incorporated approach for me that anything else seems wrong. To be able to take an empirical analytical approach it is necessary to look at the design process as an object that can be observed. And that can be difficult in this situation, because the design process has already taken place, so it is only in the participants’ memory. How can that be observed as an “experiment”? Are memories and opinions observable? If so how can different opinions of the same experience be taken into account? Etc. These are all questions that needs an answer within an empirical ontology to be empirical analytical. The study field of *architecture and everyday life* will more or less go through the same thoughts. Answers could be to use methods as structured interviews or questionnaires. You will not only have *measures*, like thing you can be counted e.g. age, income and numbers of children, but you have to define *indicator* of different situations which related to the studied (Bryman 2008). But where do those *indicators* come from? Usually it comes from the researchers understanding of the examined – and that is based in the common-sense understanding, which theoretically is founded in social science and not in natural

science.

All these thoughts return to where it all begins – the research question. It reflects the scientific approach of the work and what kind of knowledge that comes out of it. If the research question was changed to fully live up to an empirical analytical approach, the idea of the whole research will disappear. As the research question is today it reflects what is needed in the building industry today. And that is more important than what scientific approach is applied as long as the approaches is used “correct”.

Summing up on what we just have been through, it shows that to be able to achieve an integrated, holistic understanding for the future development of passive houses both the empirical analytical and the phenomenological positions are necessary. This also fits well with the overall methodical approach – the case study and mixed methods. It is therefore important, during the whole research to be aware of which approach is in play and when to switch. It requires an awareness of method and reflectivity.

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