Two Month Plan: Sustainable House of the Future

Active House 2020

Olesen, Gitte Gylling Hammershøj

Publication date:
2010

Document Version
Accepted author manuscript, peer reviewed version

Sustainable House of the Future
- Active House 2020

1. A summary

Till now focus has been mostly on reducing energy consumption in buildings from passive principles, by means of isolating the building to optimize it to keeping warm. For this, the criterion of success is relatively simple - a measured energy consumption for heating (Ellehauge 2008).
This project focuses on pointing towards a more holistic and comprehensive way of designing, optimizing and living in and with buildings. To full fill the vision of creating holistic buildings for freeing whole lives, the term Active House is applied. Contrary to passive house, which supply the building energy through for instance solar thermal panels, the Active House focuses on the whole, where various parameters within Energy, Indoor Climate and Environment are equally important (www.7).
Based on the Active House vision, VKR Holding (www22) will during two-year period build eight individual demonstration buildings in five different European countries: Seven single-family-houses, of which one is a renovation project, and one industrial/commercial building. The eight houses are geographically located across Europe, with two houses in Denmark, Germany and Austria respectively and one house in France and Britain respectively (www7). Each demonstration house will have its own distinctive character as they are built in consideration of local cultural and climatic conditions and with different teams of architects, engineers and contractors. The eight houses are all built according to a whole perspective focusing on combining an aesthetic energy design with high comfort and a good indoor climate while ensuring minimum environmental impact (www7).
When the houses are constructed, families move in to test how they experience living in and with the houses to establish whether experiences, comfort, indoor climate and energy live up to expectations.
The project consists in monitoring and measuring the houses and people to gain understanding of how the active and passive technologies, the building design, the interaction with the environment, function in relation to technicalities and energy demands as well as in relation to experience, health, wellbeing and livability. Case Study Research (Yin 2009) methodology will be applied to treat each house as an individual case. Semi-structures Interview (Kvale & Brinkman 2009) and constant monitors will amongst other measuring techniques be used to collect data, which will finally be analyzed, collated and discussed in order to develop an evaluation method for holistic evaluation of the active houses put into practice (Belton 1999).

2. The scientific content of the PhD project

A. The background for the project problem

The background for the project is to describe how the Active House initiative influence the qualities and quantitative of buildings. It is seeking verification for the statements put forward in the initial definition of the Active House vision in order to develop the Active House term and the methods for developing the future houses and products required for reducing energy consumption and CO_2 emission while creating light, healthy and livable buildings.
The PhD project is a part of the MIMA project and focuses on the method for developing the Active House based on measured and empirical data.
MIMA is an abbreviation of Measuring Interviewing Monitoring Analysis and is a measuring and developing initiative by VKR Holding. The background for the project problem and thereby MIMA is that currently no common European standard for low energy buildings exist. Therefore, it is not possible to compare low energy buildings across European borders resulting in different rules, values, calculation methods and laws for each individual country. This further carry a great infliction for instance products for the building industry and their need to be adjusted all the different factors.
The objective for the project is to develop such common European standard or definition, so future development of buildings and products for the industry, can together focus on developing the holistic technical measures necessary for and ongoing process of developing energy and CO_2-neutral Active Houses of the future.

B. An introduction

The approach to the PhD project can be divided into two parts. First is development of sustainable buildings and future requirements. Secondly is the development of a scientific method. This part will briefly state the state-of-the-art in relation to both of these.

Warming and cooling of buildings account for more than 40 per cent of the total energy consumption in the western world, and energy expenditure of each household is on the increase (www0). The global climate agenda in particular focuses on energy consumption in and of buildings. Reduction of energy consumption, switch-over to new forms of energy, renewable energy implementation, optimization of resource utilization and protection of basic natural resources are becoming increasingly urgent issues for the international community's health and safety. (www1).
In Northern Europe people spend up to 90 per cent of their time indoors. Studies suggest that diseases such as allergies and asthma can be developed as a result of poor indoor climate. Likewise, poor daylight conditions and dark buildings increase the risk of winter depression (Loft 2006). To meet the requirements for future development, buildings must be energy-optimized and have better comfort and indoor air quality. Brand new building components and technologies are available and must be integrated into buildings so as to provide the basis for a holistic approach when forming the necessary knowledge and documentation on creating balance between building, nature and human consumption. Future planners will play a significant role in the implementation of the politically formulated requirements for healthy, sustainable and CO_2 neutral solutions. But sustainability is much more than environmental considerations and consumer self-control. It is a new paradigm that affects significant parts of social developments. The formulation of the new holistic principles of sustainable development is a core task of the future building industry. (The Government, 2009)
Since the 1970s energy crises, reduction of energy consumption in buildings has primarily focused on reducing consumption for heating. An example is Passive houses, which were initially realized in Darmstadt, Germany in 1990 (Knudstrup et al. 2009). Since that time thousands of buildings have been built after the passive-house-concept in Germany and Austria. The newsworthiness of the passive house remains the same as at that time: because of its compactness, the house uses only 15kWh/m^2/year for heating, however about 55kWh/m^2/year in total when including the remaining energy consumption of the house (Ellehauge, 2008). This means that the energy consumption of a passive house is smaller than that of a standard house in 2009, which can use 70kWh/m^2/year for heating in Denmark (BR08 2009). In recent years, passive houses have been introduced in Denmark, for instance in the form of Komforthusene near Vejle. The ten different komforthuse are built according to the German passive-house-standard (www3). Also, the project Parcel Houses in Køge, which begun in 2004 is worth mentioning. These demonstration houses are based on the *Køge criteria,* meaning among other things that the houses are low energy, have a good indoor climate and are built of environmentally friendly materials and have richly planted outdoor areas (www4).
The interest in developing energy efficient and livable houses in Denmark is increasing. The most recent example is the project EnergyFlexHouse (www23) at Teknologisk Institut in Tåstrup. Two identical houses have been constructed side by side, which are to function as laboratories for development of energy sufficient solutions for homes. One house is an actual home where a family moves in to test the house and here focus is on testing the interplay between technology and user. The second house inhabits different equipment for testing and measuring and possibilities to switch between the different systems and building components to test the different coherences (www23).

Now the contour begins to emerge of a new professional discourse. However, the strategies are far from unambiguous, and sustainability is a concept of wide-ranging social, cultural and economic significance (Knudstrup et al. 2009). An attempt to promote a more holistic way of thinking when shaping the future building is reflected in the development of the Active House vision, in this project.

ACTIVE HOUSE VISION

More than 2000 years ago the Roman architect Vitruvius defined architecture as the trinity between beauty, usability and durability, in the original Latin called *Venustas, Utilitas and Firmitas* (Vitruvius 1960). This trinity is also currently forming the foundation of holistic architecture in the modern world. In the Active House vision integrity of the building is ensured by reinterpreting Vitruvius' trinity into *Energy, Indoor Climate and Environment* (www7). The symbiosis of the quantitative and qualitative values of *Energy, Indoor Climate and Environment* provides the foundation of Active House. The vision aims to set new holistic standards for future sustainable buildings (www8). On the basis of scientific assessment and evaluation of eight prototype buildings developed from the Active House vision, this project aims to develop a scientific evaluation method to form a constructive suggestion for a future certification standard for sustainable buildings.

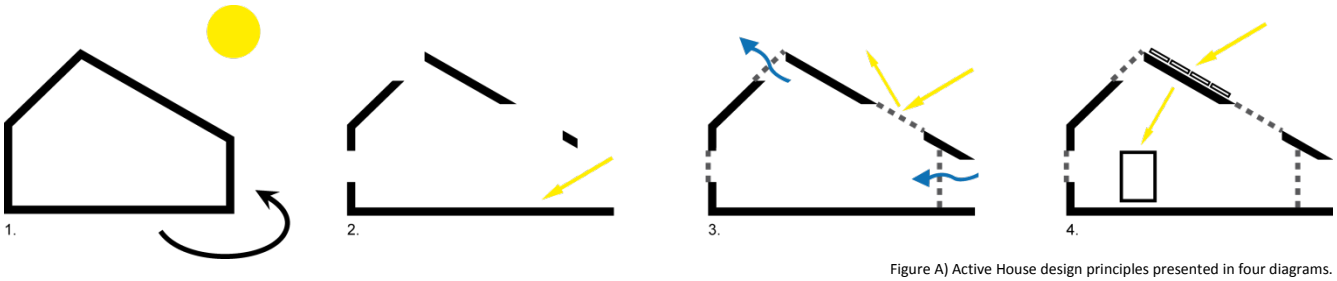


Figure A) Active House design principles presented in four diagrams.

C. Project's objectives

In the Active House vision involvement of both passive and active principles are combined with a focus on meeting comfort and experience values. Criteria of success concerns taking into account both quantitative and qualitative values.

The project objective is to prove the following research hypothesis:

- By performing **quantitative measurements** on energy, indoor climate and environment, it is possible to demonstrate that the holistic Active House vision creates buildings that are CO_2-neutral, have low energy consumption and covers its energy requirements from passive and renewable sources, fulfill the requirements laid out for creating a healthy indoor climate, and is constructed for interaction with its environment.

- By performing **qualitative measurements** as semi-structured interviews with the inhabitants, cultural probes by the inhabitants, photos and qualitative environmental registration on energy, indoor climate and environment, it is possible to demonstrate that the holistic Active House vision creates buildings that make its inhabitants experience benefits of a healthier indoor climate and effects on the surrounding environment and to discover whether they are becoming increasingly aware of their energy consumption.

- **By measuring and registering** qualitative and quantitative values within the parameters *Energy*, *Indoor Climate* and *Environment* in Active Houses, it is possible to create the foundation for **developing a holistic scientific evaluation method** for evaluating and certifying Active Houses.

- Based on the holistic evaluation method it is possible to constitute a suggestion for **quantitative and qualitative parameters** that can enter into a European Certification Standard for future energy- and CO_2-neutral Active Houses.

Pictures (including one rendering) of four of the eight Active Houses

D. Methods

The project process will be developed from the key learning method *Problem Based Learning* (PBL) (Kolmoes et al. 2004~~7~~) which will be used as a sub structure for organizing and composing all phases and aspects of the project. The PBL concept is a learning approach which originates in a problem. Thereby, focus throughout the process will be on solving project problems.
As the project skeleton consists of PBL the muscles in the structure are based on the Integrated Design Process (IDP) (Knudstrup et al 2004), a method for securing integration of different aspects. The offset for the project is interdisciplinary being the holistic Active House vision with equal focus on quantitative and qualitative values. IDP is applied as a management tool to this scientific project, both to focus on designing an integrated process and method, and to support the approach of equal focus on quantitative and qualitative research parameters (Hansen 2008).
Covering the bones and muscles is the skin of the structure - *Case Study Research* (Yin 2009) which will create a method for contemplating the eight individual buildings as individual cases. Case study is a strategy for empirical exploration of selected contemporary phenomenon in its natural context by using various data sources that can be used in a proof (Web2 2009). The sort of case study used in present project is a multiple-case design where the design of the case study will follow a replication and thereby possibly strengthen the results because the same research patters is used for examining each case and thus increasing the validity in the strength of the theory (Yin 2009).

The methodological approach is to prove the research hypothesis focuses on gathering data from the houses and following making the data comparable and then compare these to verify comparative and relative parameters.

During the initial phase of the project a set of matrixes will be designed respectively a quantitative and a qualitative matrix. Focus will be equally divided between the quantitative and the qualitative aspects of the project in order to maintain holistic focus and to support and substantiate the holistic Active House Vision. Two matrixes will be defined to describe and define which data shall be gathered from the eight case studies, respectively in *Design Phase*, *Construction Phase*, and *Measuring Phase*.

Quantitative Data
Within gathering quantitative data lie several methodological approaches. The first in gathering and making the incoming data accessible by re-calculate all *Design Phase* calculations into the same program. At this point the more appropriate calculation program seems to be Bsim (www15). The second method lies in gathering data from the houses measured by the WindowMaster control system. All the buildings have a control system by WindowMaster (www24) built into their design. This same system is incorporated into all of the demonstration houses, making it possible to extract different comparable information and data. Measurements on energy will for instance include energy consumption for heating, hot utility water, and electricity. Within measurements on indoor climate will for instance be level of daylight, air temperature, CO_2-concentration, and humidity. In relation to environment measures are for instance solar intensity, hours of sunshine, and air temperature. For each house five sets of measuring data will be extracted. One pre-evaluation before the test inhabitants move in and then quarterly evaluations while inhabited.

Qualitative Data
To gather qualitative data from the houses different *Qualitative Research Methods (*Antoft 2007*)* will be executed. The qualitative registration generates experiential, perceptional and so-called immeasurable data. The qualitative data matrix will be a synthesis of different methods within sociology, anthropology and architecture.
The first method will be the qualitative research Interview, the Semi-structured Life-world Interview (Kvale & Brinkmann 2009). The method focuses on the experience from the interviewee's subjective point of view being expressed in an interview situation, where the interviewing person leads the questions in the right direction while following the intuition of the interviewee (Kvale & Brinkmann 2009). The Semi-structural Interview will be performed twice with each test family, first, when they just move in and second time just before they move out. The time span shall create a qualitative data frame for identifying the differences in experiences.
The second method within collecting qualitative date is a Cultural Probe (www25) which is a method to access the inhabitants without directly observing them. The method consists in experiencing the world through the eyes of the

inhabitants by making a package of tasks they shall perform (www25). This can for instance be photographing certain "special" situations or writing a diary about experiencing to live in the Active House (www8).
Third part of gathering qualitative data will consist of empirical, subjective, sensing, phenomenological experiences and registrations (for instance Maurice Merleau-Ponty, Steen Eiler-Rasmussen, Juhani Pallasmaa). These will be executed by me visiting the sites and houses. Photo and movie registration will be used as an important part to visually support the registrations.

Collating data
Collation will be carried out through *Comparative Studies* (Yin 2009) (Antoft 2007). The model is relatively simple – the results of the case studies are compared to each other and the differences become focus of examination (Yin 2009). The objective is to identify why and where the cases are different to reveal the sub structure which creates these differences – quantitative and qualitative parameters from each case.

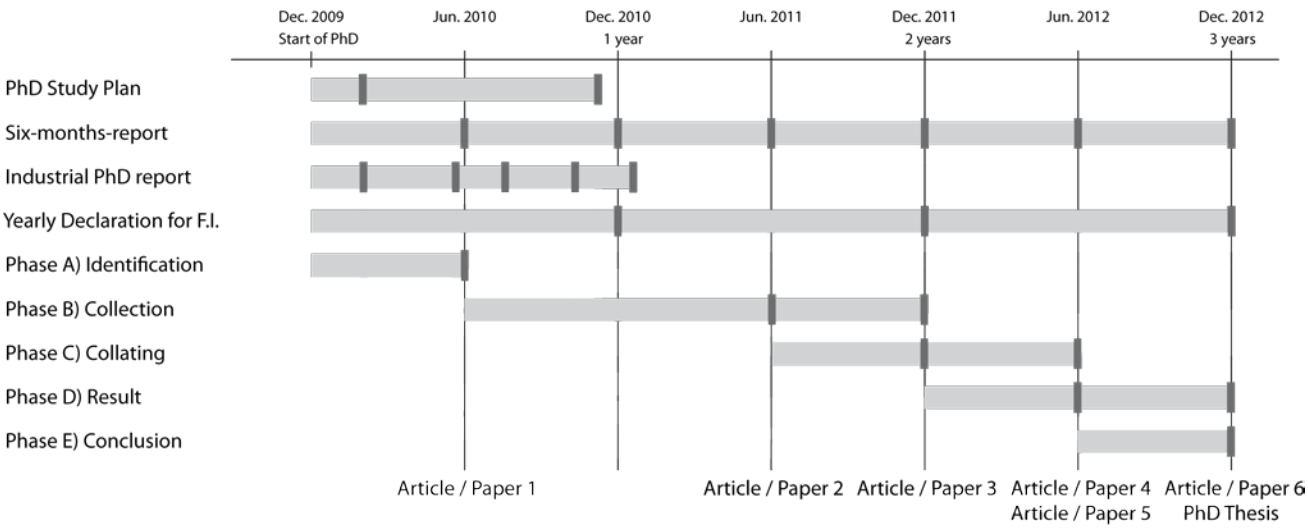
The results from the comparative studies will be subject to Multi Criteria Decision-Making (MCDM) (Belton 1990) which is a method which supports decision that shall be made on behalf of numerous and diverging results. The MCDM process aims to focus on these divergences in order to create a compromise in a so-called transparent process. (Belton 1990)

Finally, the developed evaluation method will be used to constitute a suggestion for quantitative and qualitative parameters that can enter into a European Certification Standard for future energy- and CO_2-neutral Active Houses.

E. Potential significance and application(s) of the projects expected outcome

The primary expected scientific result is the development of the holistic evaluation method. Secondary results includes, that by applying the evaluation method to eight case study houses developed from the Active House Vision, it will possible to make a suggestion to what parameters could be included in a future European Standard for Active Houses.

F. Time schedule



PHASE A) IDENTIFIKATION OF PROJECT FOUNDATION AND PROBLEM
PERIOD: February 1st 2010 till June 1st 2010
OBJECT: State-of-the-art statement for sustainable buildings in Europe.
CONTENT AND TASKS:

- Examination and analysis of the definitions and possibilities of realization of the Active House Concept.
- State-of-the-art in terms of the research themes on sustainable building, study terminology, process description, field of theory, method and methodology, and epistemology are prepared to form the scientific basis for the further project.
- Based on knowledge acquired through state-of-the-arts templates for data collection will be designed. For both parts of the project a matrix will be designed containing the specific values to be collected. Existing matrix for collection of quantitative data will be clarified and developed. Also, a template for a semi-structured life world interview (Kvale & Brinkmann, 2009) will be designed to collect a part of the qualitative data.
- Make contact with project managers for the eight active houses and a plan of execution and the collection of measurements and registrations of all houses.
- Based on the derived information clarification of the project's research hypotheses and project the problem will be formulated.
- In this phase is also participation in PhD courses with related literary studies and tutorials of relevant literature.

RESULT: Problem formulation and final research hypotheses for the project are defined. Definition is made of framework for collecting respectively quantitative and qualitative data. The overall structure for the project including timetable and an individual plan for each active house is made.
Participation in World Sustainable Energy Design conference – poster presentation (March 3rd – 5th 2010)
ARTICLE / PAPER:

1) Theoretical and Methodological Basis for Developing Method for Execution and Registration of Measurements

PHASE B) COLLECTION AND ANALYSIS OF QUANTITATIVE AND QUALITATIVE DATA
PERIOD: June 1st 2010 till December 1st 2011
OBJECT: Collection, analysis and categorization of quantitative and qualitative data from eight case studies.
CONTENT AND TASKS:

- Travel to all of the case houses for collection and registration of data. This will be performed in collaboration with local project manager.
- Perception of energy, indoor climate and environment for all of the case houses.
- Collection of pre-data and measurements from all case houses, including for instance architectural and energy idea and concept. This will be performed in collaboration with local project manager.
- Collection of quantitative data - This will be performed in collaboration with local project manager.
- Collection of qualitative data - This will be performed in collaboration with local project manager.
- The data collected will be treated to such extent that they are comparable across cases. For treatment of quantitative data used in building simulation program BSim (www15). To handle the qualitative data used the data systemization tool NVivo (Kristiansen, 2005)
- Analysis of quantitative data.
- Analysis of qualitative data.
- In this phase is also participation in PhD courses with related literary studies and tutorials of relevant literature.
- Study plan will be prepared for approval after eleven month of the project – deadline November 1st 2010.
- Industrial PhD report will be prepared on basis of Industrial PhD course seminars; focus on communication.

RESULT: Identification of significant quantitative and qualitative variable in relation to collected data.
ARTICLE / PAPER:

2) Energy, Indoor Climate and Environment in Eight Active Houses
3) Experience and livability in eight Active Houses

PHASE C) COLLATION AND DISCUSSION OF QUALITATIVE AND QUALITATIVE DATA
PERIOD: June 1st 2011 till December 1st 2012
OBJECT: Comparative Studies of quantitative and qualitative data from eight case studies.
CONTENT AND TASKS:

- Comparative studies of results from collection of data and registration will be carried out (Yin, 1995).
- The most optimum results from both quantitative and qualitative data will be evaluated and results will be chosen for forming the results of holistic evaluation method. (Belton, 1990.)

RESULT: Identification of strengths and weaknesses of the matrixes of quantitative and qualitative data, methods and analysis. There will be created new knowledge about the importance of quantitative and qualitative performance, relationships, and effects. In addition, will be designed a new approach for a holistic evaluation method of the eight cases.
ARTICLE / PAPER:

4) Method for Comparative Studies in Quantitative and Qualitative Data from Measuring Eight Active Houses
5) Evaluation of Results from Eight Measured Active Houses Collated to Estimate Developed in Evaluation Method.

PHASE D) RESULTS
PERIOD: December 1st 2011 till December 1st 2012
OBJECT: Identification and discussion of results.
CONTENT AND TASKS:

- Discussion of the results of comparative studies in the previous phase.
- Formulation of possible suggestion for future sustainable energy-neutral buildings in Europe.

RESULT: A suggestion for a holistic evaluation method for a common European standard for Active Houses in 2020.
ARTICLE / PAPER:

6) Suggestion for a Holistic Evaluation Method for a Common European Standard for Active Houses in 2020.

PHASE E) CONCLUSIONS, PERSPECTIVES AND PRESENTATION
PERIOD: June 1st 2012 till December 1st 2012
OBJECT: Development and compilation of articles and papers to the Industrial PhD Thesis.
CONTENT AND TASKS:

- Summary of sub conclusions.
- Discussion of research perspectives.
- Presentation of the PhD Thesis.

RESULT: Industrial PhD Thesis
ARTICLE / PAPER:
Industrial PhD Thesis

DISTRIBUTION OF TIME

Company / VKR Holding	50%	18 months
University / Aalborg University	50%	18 months

G. Content of the thesis

The PhD thesis will take form of a collection of papers. The collection will consist of six individual papers/articles composed at different stages in the project and in relation to different phases. Please see time schedule above.

H. Tentative titles on papers/articles, including preliminary author

Preliminary author on all of the papers/articles will be Gitte Gylling Sørensen, Mary-Ann Knudstrup, Per Heiselberg and Ellen Kathrine Hansen.

Tentative titles on articles / papers (besides see F.):

1. Theoretical and Methodological Basis for Developing Method for Execution and Registration of Measurements
2. Energy, Indoor Climate and Environment in Eight Active Houses
3. Experience and livability in eight Active Houses
4. Method for Comparative Studies in Quantitative and Qualitative Data from Measuring Eight Active Houses
5. Evaluation of Results from Eight Measured Active Houses Collated to Estimate Developed in Evaluation Method.
6. Suggestion for a Holistic Evaluation Method for a Common European Standard for Active Houses in 2020.

3. Agreement on the relationship between supervisor and student

The agreement between Gitte Gylling Sørensen (GGS) and main supervisor Mary-Ann Knudstrup (MAK) (AAU) is here presented by bringing out parts of the agreement. (EKH is main supervisor at the company VKR Holding)

GGS expect possibility for supervisor contact on a weekly basis via phone or e-mail – but will possibly not make that consequently use of it.
As a ground rule GGS calls for meetings. Alternatively EKH or MAK calls for meetings.
The notice for formal meetings should be given at least 14 days in advance (a month is preferred) to have possibility to plan transportation and stay. Readings shall be noticed and agreed in advance and sent for comments and reading at least four days in advance of the meeting with the supervisor. To GGS, email is a very good and eligible communication way for feedback.
The overall requirement is that all deadlines are met, within reasonable planning.
GGS expect to actively participate in the research group meetings of: ADPL (A&D PhD Lab), ZEB (Zero Emission Buildings), LYSnET and IHRG (Interdisciplinary Housing Research Group). MAK expects GGS to be present at research days at AAU and A&D. GGS is expected to be a part of the social PhD environment when at A&D – for instance by participating at lunch.
There is an agreement with the company to be present at the company's headquarters approximately fifty percent of the time. The remaining time will be divided between AAU, Industrial PhD Courses, PhD Courses, Networking and research groups and conferences.

4. Plan for PhD courses

Compulsory (general) course:	
Industrial PhD Course (Three seminars + Industrial Report)	7.5 ECTS
General courses:	
Writing and Reviewing Scientific Papers (9/02 and 18/05) (AAU-INS)	3.75 ECTS
Philosophy of Science and Research Methodologies (17/02-19/02) (AAA)	2.0 ECTS
Theories of Science (AAU)	2.5 ECTS
Method and social science theory (AAU)	3.25 ECTS
Specific courses:	
Sustainable building and construction – the zero energy/emissions approach (AAU-INS)	4.0 ECTS
Sustainable buildings - technical innovations and user practices (9-11/06) (AAU-INS)	3.0 ECTS
Conferences – see point 5. Below	4.0 ECTS
Total	**30.0 ECTS**

5. Plan for dissemination of knowledge and findings

Conferences:
- Plea 2011 (Passive and Low Energy Architecture) Architecture and Sustainable Development, Belgium, July 13th – 15th 2011. (www.plea2011.be/) Preparation of Paper, autumn 2010 1.0 ECTS
- Plea 2012 (Passive and Low Energy Architecture) Directory and place unknown Preparation of Paper, autumn 2011 1.0 ECTS
- World Sustainable Energy Days 2010 (WSED) Wels, Austria, 3rd-5th March 2010 (www.wsed.at)
- World Sustainable Energy Days 2011 (WSED) Object and place unknown, Preparation of Paper, autumn 2011 1.0 ECTS
- World Sustainable Energy Days 2012 (WSED) Object and place unknown Preparation of Paper, autumn 2012 1.0 ECTS
- European Council for an Energy Efficient Economy (ECEEE) (2011) (www.eceee.org/)

Total (ECTS points are transferred to 4. – see above) 4.0 ECTS

Cooperation in relation to ongoing national and international research projects:
- IEA Task 40 Annex 52 - International Energy Agency (www.iea-shc.org/task40/)
- Zero Emission Buildings - Strategic Research Center for CO_2-neutral construction, Aalborg University (www.zeb.aau.dk/)
- MCAH (Minimum Configuration Home Automation) (www.), Ingeniør Højskolen I Århus, Alexandra Instituttet I Århus

Other dissemination:
- VELUX Daylight Symposium - Every 2 years (www.thedaylightsite.com/)
- LYSnET (www.lysnet.com/pages/lysnet.dk/forside.php)
- ADPL (A&D PhD Lab, AAU)
- IHRG (Interdisciplinary Housing Research Group)
- SAG (Sustainable Architecture Group at A&D, AAU)
- Lecturing at Aalborg University at Architecture and Design
- Project presentation in company (in relation to Industrial PhD Courses)

6. Relevant agreements on immaterial rights to patents

In the employment contract between VKR Holding and Gitte Gylling Sørensen a set of paragraphs are composed to define agreements on immaterial rights to patents and the like. Relevant agreements are outlined below.

Results accomplished by the employee when, during her engagement in the company and work with the Industrial PhD Project and which as regards the VKR Group's fields of activity in a wide range belongs to the company without any separately privilege. The company has the same privilege even though the result is not covered by the VKR Group's field of activities, if the result concerns an employee of the company or another company within the VKR Group.
Inventions, production methods and other technical improvements (henceforth called inventions) which the employee may do or invent during as part of her employment in the company and which concern the VKR Group's field of activities in a wide range, whether concerning physical products, improvements of products and/or production or measuring methods, inventions which can be taken out a patent for or other is property of the company without the company applying any separate compensation.
As for works that the employee may produce applies equally as to inventions. The copyright to a work that the employee may produce during his employment with the Company, rests with the employee, but is considered fully transferred to the company, which obtains all transferable rights in the work, including the right to higher utilization, changes and subsequent resale to third parties.

Furthermore, an agreement between VKR Holding and Aalborg University is composed which will not be outlined here.

7. Plans for external collaboration

Currently there are no plans for a stay in connection to research institutions.
However, there has been made preliminary arrangements for collaboration with research institutes The Alexandra Institute in Århus, Denmark (www16), Fraunhofer-Gesellschaft in Freiburg, Germany (www17) and BRE in England (www21).
The Alexandra Institute is a research-based company that bridges the gap between the IT corporate sector, research and education. The Institute is currently doing a research project on among others one of the demo house Home for Life, called Minimum Configuration Home Automation (MCHA) (www16). The research project examines how different IT-solutions for the home, developed on the basis of user driven innovation, can be configured in order to be practicable and relevant to the users. The PhD project will amongst other things benefit from the qualitative research methods practiced and developed by the institute.
Fraunhofer-Gesellschaft is a research institute with more than 80 research units. The Fraunhofer Institute for Solar Energy Systems (ISE) is involved in calculations in relation to developing the demo houses Solar Active House and House of the Future (www17) (www18). The PhD project will benefit from the knowledge the Fraunhofer Institute has generated during the process of co-developing the houses, in relation to quantitative calculation models.
The research institutes are attached in order to supervise in their individual core areas of research and knowledge.
In addition to these expected collaborations, there are plans to carry out trips to the various demonstration houses for research, interviews site visits and the like.
BRE is a union which provides a complete range of consultancy, testing, certification, commissioned research and training services covering all aspects of the build environment and associated industries (www21).

8. Financing budget for the PhD

Industrial PhD is financed by VKR Holding A/S and Forsknings og Innovationsstyrelsen.
Provisionally budget: 1.610.000 kr.

9. List of references

List of references is included as an.