M.Sc. in Indoor Environmental Engineering

Master's Thesis Ideas 2011

Jensen, Rasmus Lund; Heiselberg, Per; Larsen, Olena Kalyanova; Nielsen, Peter V.; Pomianowski, Michal Zbigniew; Le Dréau, Jérôme; Zajas, Jan Jakub

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Rasmus Lund Jensen
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Jérôme Le Dréau
Jan Jakub Zajas

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by

Rasmus Lund Jensen
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Michal Zbigniew Pomianowski
Jérôme Le Dréau

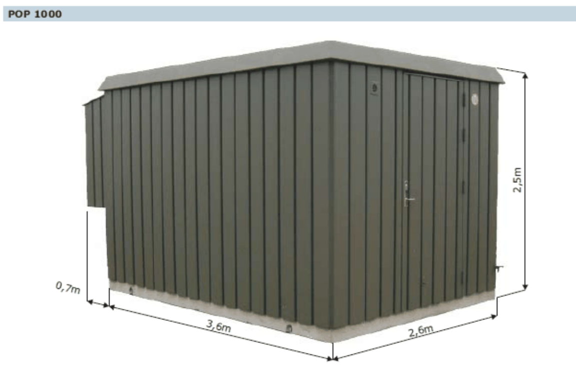
November 2009

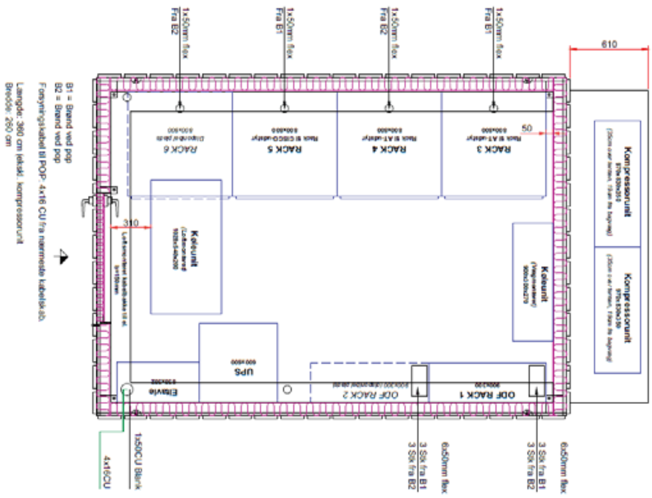
Energioptimering af bredbåndsstationer

Problemstilling

HEF er i gang med at opstille POP stationer over hele Nordjylland. Stationerne er hjertet i HEFs nye fibernet. I dag udstyres POP'erne med mekanisk køling for at sikre serverne mod overophedning. Dette indbære en del omkostninger, dels til energiforbrug til kølingen og dels til vedligehold af den mekaniske køling. Derfor har HEF et ønske om at kunne udnytte passiv og naturlig køling til at sikre mod overophedning.

HEF har siden juli logget temperatur og elforbrug i to POP'er i Aars, hvor udeklimadata også er tilgængelige fra DMI. Det vil derfor være muligt at udarbejde en matematisk model for temperaturforholdene i POP'erne og benytte målingerne til at kalibrere modellen.





Mål

At opnå viden om, beregning og simulering af energiforbrug som værktøj til at sikre et behageligt temperaturniveau og lavt energiforbrug i bygninger. Projektet giver god mulighed for at sammenligne modeller og virkelighed, da målinger af temperatur og energiforbrug sammenlignes med resultater fra simuleringer. Målet er at den studerende opnår viden og færdigheder indenfor bygningsenergisimulering og passiv køling.

Projektindhold

For eksempel behandler projektet følgende forhold

- Kvalitetssikring af målinger
- Beregning og simulering af energistrømme i en bygning
- Passiv køling, herunder naturlig ventilation

Forslagsstiller

Rasmus Lund Jensen

TABS - Introduction

Future tightening of energy legislation calls for better and multifunctional solutions. Newly constructed buildings will have to fulfill more strict demands for the energy use. This new regulations are scheduled to come into force in 2010, 2015 and then 2020. In 2020, the total primary energy use of buildings is forecasted to be reduced by about 75% with respect to demands in 2006.

Such a dramatic improvement in energy use in buildings will require development of new technologies that will be able to provide normative indoor quality and at the same time fulfill new energy frames.

The goal of the project is to investigate the new technology of a prefabricated concrete hollow core deck element that will combine high heat storage capacity and at the same time will actively respond on heating and cooling demand. In this project, the concept of increasing the heat storage capacity in the hollow core deck element is introduced by integration of microencapsulated phase change material (PCM). Moreover, the concrete deck can act as a heat sink or heat source due to its thermal activation. The thermal activation is introduced to the deck by the pipes in which will circulate water of defined temperature. In case of heating water temperature is higher than surrounding and in case of cooling is lower than surrounding of the deck.

Methodology

Heat storage capacity of the hollow core deck element will be determined by means of experimental investigations. During the experiments the deck will be exposed to series of various dynamic thermal loads. Set of experiments for the hollow core deck element with and without PCM shall be conducted. Finally, heat storage capacity and temperature shift in time in the deck shall be calculated and compared for case with and without PCM.

Secondly, set of experiments for different temperature profiles, time of activation, water flow mass, and various water temperature, shall be planned for the case when deck is activated (water is flowing though the deck). Cooling capacity range of the deck shall be calculated with regards to related parameters.

Results from the experimental investigations can be then used as a base for validation/improvement of the existing models for energy storage, PCM materials, and floor heating/cooling in such and advanced simulation tool (BSim).

Objectives

- To develop initial measurement methodology for heat storage capacity of semi-full scale prefabricated construction element with integrated PCM.
- To calculate cooling capacity range of thermally activated hollow core deck element, with respect to various related parameters, for example, (water temperature, water mass flow, surrounding temperature, heat transfer coefficient on the deck surface…)
- Have validated existing calculation models for energy storage, PCM materials, floor heating/cooling in BSim simulation tool.

Forslagsstiller

Per Heiselberg, Michal Pomianowski & Rasmus Lund Jensen

Investigation of energy flows in thermally activated building constructions

Project overview:

In Low Energy Buildings, the extended thermal insulation and enhanced air-tightness removes the need for high temperature heating. Highly varying heat loads due to solar radiation and building occupation will determine the needs for heating or cooling. Low temperature heating and high temperature cooling can therefore be used in new buildings in order to increase its energy efficiency (low exergy systems).

The overall scope of the project is by activating the building construction to develop a building system which has the capability to dynamically adjust physical properties and energetic performance according to changing demands, indoor/outdoor conditions and energy availability. This ability could pertain to energy capture, energy transport, energy storage, energy shifting and reduction of peak load as well as utilization of renewable energy sources.

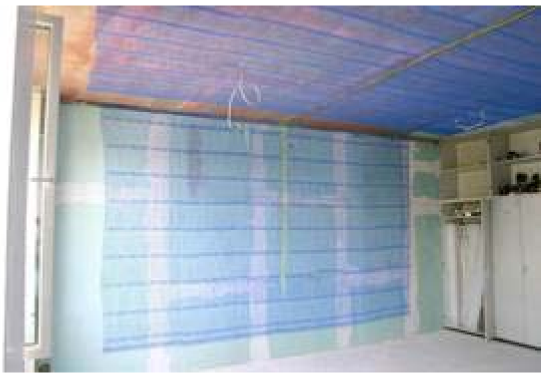
This project focuses on the use of water based systems embedded in the building structure either in the surface of the construction, or in the main concrete construction slabs:

- By adjusting the surface temperature, the room temperature can be controlled individually with a short time response.
- By activating the energy storage capability of a building structure, Thermo-Active Building Systems (TABS) have the potential to reduce peak loads. It offers the energy supply grid a high flexibility by its ability to shift energy needs to periods of high production or low requirements. Moreover TABS split the control of room temperature and indoor air quality on separate systems.

This project aims at developing new methods for analysis and simulation of energy flows in activated building constructions in low energy buildings in order to be able to investigate the possibilities for transferring heating-cooling demand to night-time and none peak hours or between different zones in a buildings, to investigate the acceptable time-frame for buildings to be disconnected from the energy grid and how much the peak load can be reduced by activating the building mass.

Description of the project:

One of the main challenges of this project is to investigate the possibilities of a surface system, which could be composed of capillary micro pipes embedded in a gypsum layer. In order to investigate the potential of such a system, a calculation method has to be developed on the basis of previous works. It could be of interest as well to determine which configuration, hydraulic layout and control strategy are the more suitable to improve the efficiency of this system.



The project will mainly involve theoretical investigations and use of simulation programs. Knowing German would be helpful.

Forslagsstiller
Per Heiselberg, Jérôme Le Dréau & Rasmus Lund Jensen

CLIMAWIN project

In Europe only 2% houses are newly built using green designs. Hence the majority of the old buildings need to be upgraded to meet the European energy efficiency targets. The window industry's response to the problem has been to improve thermal envelopes using better insulation materials in frames, glass, as well as reducing air leaks. These concerns have led to a sealing of building envelope also in the old buildings which are not equipped with HVAC systems, resulting in a severe deterioration in indoor air quality (IAQ) in these buildings.

CLIMAWIN seeks to decouple the window industry's innovation effort in energy efficiency from the conventional trade-off on indoor air quality by offering simultaneous and radical improvements on both parameters - thus effectively bridging the currently conflicting demands of the indoor air quality dilemma and building's energy efficiency.

Through the optimization of thermal properties, storage of solar energy and minimization of night-time heat loss, the intelligent CLIMAWIN system will significantly improve energy efficiency in both residential and in commercial buildings. These improvements will be realized by introducing novel and embedded solar energy storage and night-blinding technologies together with an advanced control system.

Through highly innovative technology, which includes embedded smart sensors, communication technology and actuators, CLIMAWIN will enable controlled natural ventilation and thus the conditions for drastically improved IAQ and optimal air flow control. It can replace and/or be integrated with HVAC systems to significantly enhance their performance and reduce energy consumption. A control strategy will be based on real-time monitoring of key parameters such as air humidity, occupancy and air temperature in the occupied zone.

The first generation of climawin-window is already on the market and it functions as a simple ventilated window. Taking a departure from already existing window the experimental investigation of its thermal, ventilation and energy performance can be made. These can be supported with a literature review and some initial investigations of different window typologies and dimensions, in order to perform parameter evaluation for optimal window configuration in different climatic zones.

Next, the energy performance of the window can be significantly improved by minimizing night-time heat loss and optimizing day-time solar gains. It is assumed that the night-time heat loss and the day-time solar gains can be optimized via shading device and/or night blind.

There are a few challenges in this project. One of them is to discover what are the properties the solar shading device/night blind must have (i.e. integrated phase change materials, vacuum insulation, selective coatings, etc.). Another challenge is to find out what is the optimal position of solar shading device built in the window (next to the inner or outer pan of the window), what window configuration is more suitable for one or another type of shading device and what are the efficient calculation methods can be used for evaluation of window performance.

The project will involve experimental and theoretical investigations, use of simulation programs, etc.

Forslagsstiller

Olena Larsen, Per Heiselberg & Rasmus Lund Jensen

Til: Rasmus Lund Jensen

Projektforslag til Institut for Byggeri og Anlæg, Energi og Indeklima.

17/11/2010
pdp/hls

Selvlærende model til forudsigelse af huses energibehov

Neogrid Technologies deltager i forskningsprojektet "Fra vindkraft til varmepumper"[1]. Det banebrydende projektet er det eneste af sin art i verden, og det går ud på at styre 300 intelligente varmepumper, som om de var et stort energilager, der kan gemme el som varme. Husejerne skal være med til at udvikle fremtidens, intelligente energisystem, hvor vindkraft udnyttes til at fortrænge fossile brændsler til opvarmning. Med varmepumperne medvirker husejerne aktivt til at få mere vedvarende energi i Danmark.

El kan ikke gemmes. El skal bruges i samme sekund, det produceres, fordi man i dag ikke har teknologi til at lagre el. Derfor er stigende mængder vindenergi en udfordring for elsystemet, fordi energien kommer, som vinden blæser. Ved at koble 300 varmepumper sammen, kan man skabe et stort energilager, hvor el lagres som varme. Når det blæser meget, og der er mere grøn strøm, end der er forbrug til, så gemmes strømmen ved hjælp af varmepumperne som varme. Når det er vindstille, og der er brug for al den strøm, som produceres, så stopper varmepumperne med at producere varme, og husene henter varmen fra den lagrede varme.

Udover at styre varmepumperne intelligent i relation til elnettets behov, ligger der en betydelig udfordring og forudsætning i at kunne forudsige de enkelte husstandes energibehov så præcist som muligt, og med så lidt involvering fra husets beboere som muligt.

Projektet fra vindkraft til varmepumper

Vindkraft til varmepumper er i realiteten tre projekter, der fra hvert sit udgangspunkt bidrager til at belyse:

- I hvor høj grad det rent faktisk er muligt at få forbrugerne til at flytte deres forbrug på baggrund af prissignaler fra elsystemet.
- Hvordan kan den intelligente styring mellem elsystem, elhandler og varmepumpe indrettes.

[1] Se beskrivelsen hos Energinet: http://www.energinet.dk/DA.../Fra-vindkraft-til-varmepumper.aspx

Neogrid Technologies ApS
Niels Jernes Vej 10
DK-9220 Aalborg East
DENMARK
info@neogrid.dk
www.neogrid.dk
VAT no: 32773818
Bank account 9314 4574122134
IBAN: DK1193144574122134
SWIFT: SPNODK22

- Hvilke forretningsmodeller og markedsdesign, kan understøtte udviklingen af det intelligente elforbrug.
- I hvor høj vil det i praksis være muligt at få varmepumper til at understøtte et elsystem med meget vindkraft.

Problemstilling
Indeværende projektforslag tager udgangspunkt i problemstillingen skitseret i ovenstående varmepumpeprojekt. For aktivt at kunne flytte energiforbruget i huse uden at kompromittere beboernes komfortopfattelse, er det nødvendigt at kunne forudsige det fremtidige energiforbrug præcist, så den rette mængde energi på forhånd kan indkøbes og reguleringen af husets komfort i tide kan justeres på plads.

Projektet skal opbygge en adaptiv model for et huset, der lærer huset at kende på baggrund af historiske data, så modellen efter en oplæringsperiode kan forudsige et ret præcist energiforbrug for de kommende dage. Dette skal ske med en tidsopløsning på mindre end en time. Modellen skal tage højde for:

- Brugeradfærd– hvordan bruger familien varme og vand, udluftning,...
- Husets fysiske egenskaber (varmeakkumuleringsevne, isoleringsgrad, tæthed, areal, konstruktion, alder,...)
- Solindfald, aktuelle og prognoser
- Vejrprognoser
- ...

På baggrund af modellen skal følgende resultater kunne leveres:

- Husets samlede energibehov 1 til 48 timer frem i tiden med en given tidsopløsning
    - Brugsvand
    - Varme
- Levere fejlsandsynlighed på estimater
- Levere estimerede modelparametre, der siger noget om husets klimaskærm, varmeakkumuleringsevne, isoleringsgrad, tæthed,...
- Løbende holde modellen opdateret så den gradvist bliver mere præcis

Resultatet fra modellen skal kunne anvendes i en overordnet optimering, der samtidig tager højde for elpriser, samt begrænsninger i forsyningen, så energien kan indkøbes og leveres billigst muligt til huset.

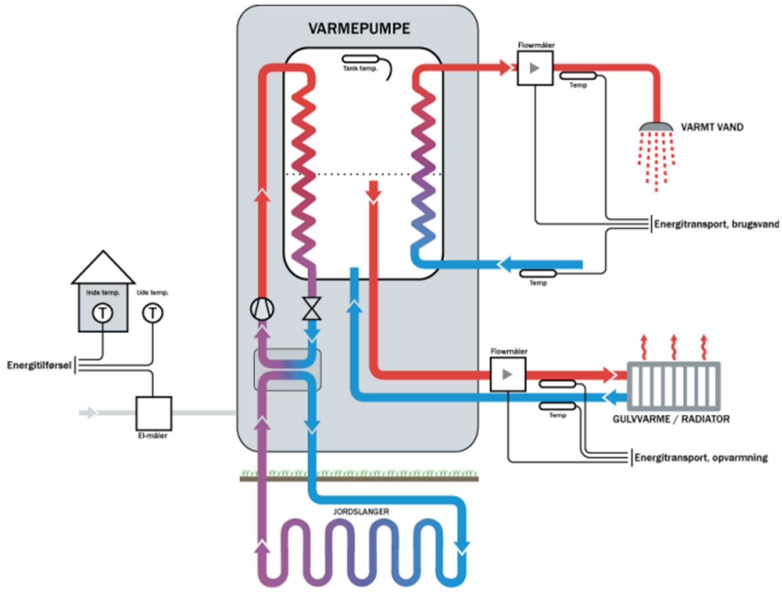
Datagrundlag
I varmepumpeprojektet er der tilknyttet 300 huse, hvorfra der løbende bliver opsamlet målinger fra huset og varmepumpen.

Der er 300 huse tilknyttet forskningsprojektet, som har fået installeret sensorer, der løbende opsamler data fra huset samt varmepumpen. Herved kan en rimelig nøjagtig model for leveret effekt for huset stilles op. Følgende sensordata logges og tidsstemples:

- Rumvarme (temperatur ind/ud og flow)
- Brugsvand (temperatur ind/ud, flow og temperatur i brugsvandstank)
- Varmepumpens elforbrug

- BBR data (areal, konstruktion, alder osv.)
- Antal beboere i husstanden og deres alder
- Vejrprognose (vind, temperatur og skydække)

Sensor placeringen omkring varmepumpen er illustreret i Figur 1 herunder.



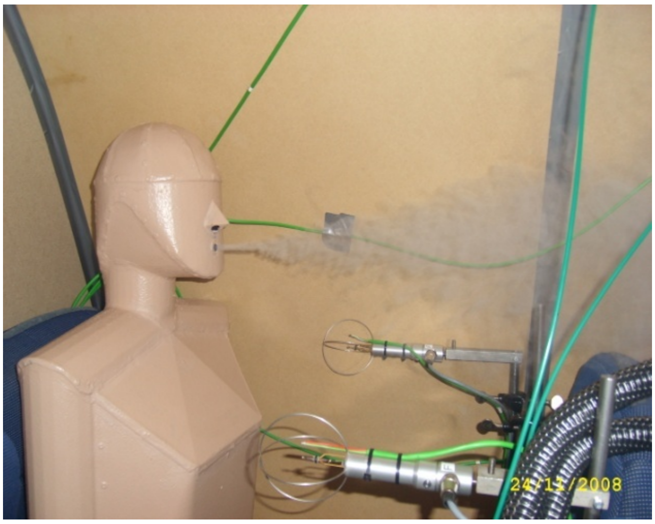
Figur 1

Neogrid Technologies håber det skitserede projektforslag vækker jeres interesse og stiller selvfølgelig op til en uddybende diskussion, såfremt I finder det nødvendigt.

Aircraft cabin

Measurement of cross infection risk in the aircraft cabin with 4 manikins. Flow rate 40 L/s total, 280 W. Different combinations of source and target. Also a case with a standing manikin (crew). Measurements in the cases: mixing ventilation, displacement ventilation and vertical ventilation. See 9. sem. 2010 rapport.

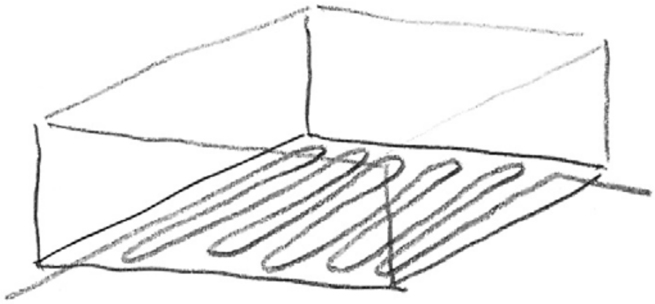
Measurements which include the personalized ventilation devise. Supply at head height and at the back.



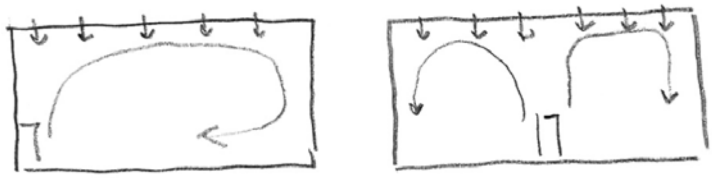
Draught is a major problem in an aircraft cabin. Study how the supply of air through the PV system can reduce the draught in the cabin because it reduces the air supply to the general ventilation.

Diffuse ceiling inlet – Used at Widex Headquarter

Study the stability problem with this system. Heat cables at the floor to generate even heat distribution. Slow increase of load and flow rate to see if we can build up an unsteady situation.



Study of heating mode. How large should a source be to generate the necessary recirculating flow? Optimal location?



Head load: Two manikins, two computers and two lamps (as usual for our standard case).

Cover a larger and larger part of the ceiling with plastic to study any increase in draught, and therefore a reduction in the maximum thermal load which can be handled.

Forslagsstiller:
Peter V. Nielsen & Rasmus Lund Jensen

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