Elsabet Nomonde Noma Nielsen - DTU Orbit (24/09/2018)

Elsabet Nomonde Noma Nielsen

Organisations

Senior Researcher, Department of Civil Engineering
04/07/2003 → present
ean@byg.dtu.dk
VIP

Energy and Services
13/06/2018 → present
VIP

Akademingeniør, Department of Buildings and Energy
04/07/2003 → 07/04/2016 Former
ean@ibe.dtu.dk
VIP

Section for Building Energy
04/06/2015 → 13/06/2018 Former
VIP

Section for Building Physics and Services
25/02/2012 → 04/06/2015 Former
VIP

Publications:

Yearly thermal performances of solar heating plants in Denmark – Measured and calculated
The thermal performance of solar collector fields depends mainly on the mean solar collector fluid temperature of the collector field and on the solar radiation. For Danish solar collector fields for district heating the measured yearly thermal performances per collector area varied in the period 2012–2016 between 313 kWh/m² and 577 kWh/m², with averages between 411 kWh/m² and 463 kWh/m². The percentage difference between the highest and lowest measured yearly thermal performance is about 84%. Calculated yearly thermal performances of typically designed large solar collector fields at six different locations in Denmark with measured weather data for the years 2002–2010 vary between 405 kWh/m² collector and 566 kWh/m² collector, if a mean solar collector fluid temperature of 60 °C is assumed. This corresponds to a percentage difference between the highest and lowest calculated yearly thermal performance of about 40%. This variation is caused by different weather conditions from year to year and from location to location. Approximately half of the variations of yearly thermal performances can be related to variable weather conditions.

General information

State: Published
Organisations: Department of Civil Engineering, Section for Building Energy, Danish Meteorological Institute
Authors: Furbo, S. (Intern), Dragsted, J. (Intern), Perers, B. (Intern), Andersen, E. (Intern), Bava, F. (Intern), Nielsen, K. P. (Eksterm)
Pages: 186-196
Publication date: 2018
Main Research Area: Technical/natural sciences

Publication information

Journal: Solar Energy
Volume: 159
ISSN (Print): 0038-092X
Ratings:
  BFI (2018): BFI-level 1
  Web of Science (2018): Indexed yes
  BFI (2017): BFI-level 1
  Scopus rating (2017): CiteScore 4.89 SJR 1.615 SNIP 1.791
  Web of Science (2017): Indexed yes
  BFI (2016): BFI-level 1
  Scopus rating (2016): CiteScore 4.52 SJR 1.504 SNIP 1.746
Availability of high quality weather data measurements

In the period 2016-2017 the project “Availability of high quality weather data measurements” is carried out at Department of Civil Engineering at the Technical University of Denmark. The aim of the project is to establish measured high quality weather data which will be easily available for the building energy branch and the solar energy branch in their efforts to achieve energy savings and for researchers and students carrying out projects where measured high quality weather data are
Experimental investigations on solar heating/heat pump systems for single family houses

In the period 2013-2017 the project “Experimental investigations on solar heat pump systems for single family houses” is carried out at Department of Civil Engineering, Technical University of Denmark. The aim of this project is to increase the knowledge of the heat and mass transfer in the combined solar heating/heat pump system type when the heat pump makes use of a horizontal ground source heat exchanger. The knowledge is gained by experimental investigations on a solar heating/heat pump system and forms the basis for improved marketed combined solar heating/heat pump systems.
Bibliographical note

Applications of Polysun at DTU Denmark

General information
State: Published
Organisations: Department of Civil Engineering, Section for Building Energy
Authors: Andersen, E. (Intern)
Number of pages: 5
Publication date: 2016
Main Research Area: Technical/natural sciences

Calculated thermal performance of solar collectors based on measured weather data from 2001-2010

This paper presents an investigation of the differences in modeled thermal performance of solar collectors when meteorological reference years are used as input and when multi-year weather data is used as input.

The investigation has shown that using the Danish reference year based on the period 1975-1990 will result in deviations of up to 39 % compared with thermal performance calculated with multi-year the measured weather data. For the newer local reference years based on the period 2001-2010 the maximum deviation becomes 25 %.

The investigation further showed an increase in utilization with an increase in global radiation. This means that besides increasing the thermal performance with increasing the solar radiation, the utilization of the solar radiation also becomes better.
Measurements of the angular distribution of diffuse irradiance

Advanced solar resource assessment and forecasting is necessary for optimal solar energy utilization. In order to investigate the short-term resource variability, for instance caused by clouds it is necessary to investigate how clouds affect the solar irradiance, including the angular distribution of the solar irradiance. The investigation is part of the Danish contribution to the taskforce 46 within the International Energy Agency and financed by the Danish Energy Agency. The investigation focuses on the distribution of the diffuse solar irradiance and is based on horizontal measurements of the solar irradiance from 8 different parts of the sky as well as horizontal measurements of the total beam and total diffuse irradiance.

General information

State: Published
Organisations: Department of Civil Engineering, Section for Building Energy , Danish Meteorological Institute
Authors: Andersen, E. (Intern), Nielsen, K. P. (Ekstern), Dragsted, J. (Intern), Furbo, S. (Intern)
Number of pages: 8
Pages: 729-736
Publication date: 2015
BFI conference series: International Conference on Solar Heating and Cooling for Buildings and Industry (5020045)
Main Research Area: Technical/natural sciences

Publication information

Journal: Energy Procedia
Volume: 70
ISSN (Print): 1876-6102
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.44 SJR 0.495 SNIP 0.799
BFI (2016): BFI-level 1
Inlet stratification device
An inlet stratification (5) is adapted to be arranged vertically in a tank (1) during operation. The stratification device (5) comprises an inlet pipe (6) formed of a flexible porous material and having a lower and upper end. The lower end of the inlet pipe (6) is connected to a bottom cap (10) with an inlet passage way (16). The upper end of the inlet pipe (6) is connected with a top cap (9). The top cap (9) and the bottom cap (10) are mutually connected by means of a wire (8) and the top cap (9) is configured as a floating device providing a buoyancy force larger than the downwardly directed force due to the wire (8), the inlet pipe (6) and any deposited on the above pass during operation.

General information
State: Published
Organisations: Department of Civil Engineering, Section for Building Physics and Services
Authors: Spanggaard, M. (Ekstern), Andersen, E. (Intern)
Publication date: 2014

Investigations of Intelligent Solar Heating Systems for Single Family House
Three differently designed intelligent solar heating systems are investigated experimentally in a test facility. The systems provide all the needed yearly heating demand in single family houses. The systems are based on highly stratified tanks with variable auxiliary heated volumes. The tank is a tank in tank heat storage with domestic hot water in the inner tank and space heating water in the outer tank. The total tank volume is 750 liters and the solar collector area is 9 m². The
The auxiliary energy supply system is based on electrical heating element(s)/heat pump and is different for all three systems. The system will be equipped with an intelligent control system where the control of the electrical heating element(s)/heat pump is based on forecasts of the variable electricity price, the heating demand and the solar energy production. By means of numerical models of the systems made in Trnsys, the control strategy of intelligent solar heating systems is investigated and the yearly auxiliary energy use of the systems and the electricity price for supplying the consumers with domestic hot water and space heating are calculated.

**General information**

State: Published  
Organisations: Department of Civil Engineering, Section for Building Physics and Services  
Authors: Andersen, E. (Intern), Chen, Z. (Intern), Fan, J. (Intern), Furbo, S. (Intern), Perers, B. (Intern)  
Pages: 1-8  
Publication date: 2014  
BFI conference series: International Conference on Solar Heating and Cooling for Buildings and Industry (5020045)  
Main Research Area: Technical/natural sciences

**Publication information**

Journal: Energy Procedia  
Volume: 48  
ISSN (Print): 1876-6102  
Ratings:  
BFI (2018): BFI-level 1  
BFI (2017): BFI-level 1  
Scopus rating (2017): CiteScore 1.44 SJR 0.495 SNIP 0.799  
BFI (2016): BFI-level 1  
Scopus rating (2016): CiteScore 1.16 SJR 0.464 SNIP 0.598  
Web of Science (2016): Indexed yes  
BFI (2015): BFI-level 1  
Scopus rating (2015): SJR 0.359 SNIP 0.562 CiteScore 0.92  
BFI (2014): BFI-level 1  
Scopus rating (2014): SJR 0.429 SNIP 0.807 CiteScore 1.09  
BFI (2013): BFI-level 1  
Scopus rating (2013): SJR 0.42 SNIP 0.778 CiteScore 1.02  
ISI indexed (2013): ISI indexed no  
Web of Science (2013): Indexed yes  
Scopus rating (2012): SJR 0.411 SNIP 0.55 CiteScore 1.08  
ISI indexed (2012): ISI indexed no  
Web of Science (2012): Indexed yes  
Scopus rating (2011): SJR 0.877 SNIP 1.45 CiteScore 2.42  
ISI indexed (2011): ISI indexed no  
Scopus rating (2010): SJR 0.416 SNIP 0.91  
Web of Science (2009): Indexed yes  
Original language: English  
Stratification, Variable auxiliary heated volume, Solar heating system, Smart control  
Electronic versions:  
Investigations_of_intelligent_solar_heating.pdf  
DOIs:  
10.1016/j.egypro.2014.02.002  
Source: dtu  
Source-ID: n:oai:DTIC-ART:elsevier/449476336::38813  
Publication: Research - peer-review › Conference article – Annual report year: 2014

**Upgrade and extension of the climate station at DTU Byg**

In the period 2013-2014 the project “Upgrade and Extension of the Climate Station at DTU Byg” is carried out at DTU Byg. The aim of the project is to renew the hardware and the software for data acquisition and monitoring, exchange cables and cable connections in order to avoid interference of electrical noise from the surroundings and exchange worn out equipment. Further, the aim is to make measured data from the climate station easily available for the users.
Solar/electric heating systems for the future energy system

The project “Solar/electric heating systems in the future energy system” was carried out in the period 2008-2013. The project partners were DTU Byg, DTU Informatics (now DTU Compute), DMI, ENFOR A/S and COWI A/S. The companies Ajva ApS, Ohmatex ApS and Innogie ApS worked together with the project partners in two connected projects in order to develop solar/electric heating systems for laboratory tests. The project was financed by the Danish Agency for Science, Technology and Innovation under the Danish Council for Strategic Research in the program Sustainable Energy and Environment. The DSF number of the project is 2104-07-0021/09-063201/DSF. This report is the final report of the project.

The aim of the project is to elucidate how individual heating units for single family houses are best designed in order to fit into the future energy system. The units are based on solar energy, electrical heating elements/heat pump, advanced heat storage tanks and advanced control systems.

Heat is produced by solar collectors in sunny periods and by electrical heating elements/heat pump. The electrical heating elements/heat pump will be in operation in periods where the heat demand cannot be covered by solar energy. The aim is to use the auxiliary heating units when the electricity price is low, e.g. due to large electricity production by wind turbines.

The unit is equipped with an advanced control system where the control of the auxiliary heating is based on forecasts of the electricity price, the heat demand and the solar energy production. Consequently, the control is based on weather forecasts.

Three differently designed heating units are tested in a laboratory test facility. The systems are compared on the basis of:
- energy consumption for the auxiliary heating
- energy cost for the auxiliary heating
- net utilized solar energy

General information
State: Published
Organisations: Department of Civil Engineering, Section for Building Physics and Services, Department of Applied Mathematics and Computer Science, Dynamical Systems, Center for Energy Resources Engineering, Scientific Computing, Department of Electrical Engineering, Danish Meteorological Institute, COWI A/S, Innogie ApS
Number of pages: 617
Publication date: 2013

Publication information
Publisher: Technical University of Denmark, Department of Civil Engineering
ISBN (Print): 9788778773739
Original language: English
A simplified heat pump model for use in solar plus heat pump system simulation studies

Solar plus heat pump systems are often very complex in design, with sometimes special heat pump arrangements and control. Therefore detailed heat pump models can give very slow system simulations and still not so accurate results compared to real heat pump performance in a system. The idea here is to start from a standard measured performance map of test points for a heat pump according to EN 14825 and then determine characteristic parameters for a simplified correlation based model of the heat pump. By plotting heat pump test data in different ways including power input and output form and not only as COP, a simplified relation could be seen. By using the same methodology as in the EN 12975 QDT part in the collector test standard it could be shown that a very simple model could describe the heat pump test data very accurately, by identifying 4 parameters in the correlation equation found.

General information
State: Published
Organisations: Department of Civil Engineering, Section for Building Physics and Services, SP Technical Research Institute of Sweden
Authors: Perers, B. (Intern), Andersen, E. (Intern), Nordman, R. (Ekstern), Kovacs, P. (Ekstern)
Pages: 664-667
Publication date: 2012
Main Research Area: Technical/natural sciences

Publication information
Journal: Energy Procedia
Volume: 30
ISSN (Print): 1876-6102
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.44 SJR 0.495 SNIP 0.799
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.16 SJR 0.464 SNIP 0.598
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.359 SNIP 0.562 CiteScore 0.92
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.429 SNIP 0.807 CiteScore 1.09
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.42 SNIP 0.778 CiteScore 1.02
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
Scopus rating (2012): SJR 0.411 SNIP 0.55 CiteScore 1.08
ISI indexed (2012): ISI indexed no
Web of Science (2012): Indexed yes
Scopus rating (2011): SJR 0.877 SNIP 1.45 CiteScore 2.42
ISI indexed (2011): ISI indexed no
Scopus rating (2010): SJR 0.416 SNIP 0.91
Web of Science (2009): Indexed yes
Original language: English
Heat pump, Correlation model, Simulation
Source: dtu
Source-ID: u::6347
Publication: Research - peer-review › Conference article – Annual report year: 2012
Development of seasonal heat storage based on stable supercooling of a sodium acetate water mixture

A number of heat storage modules for seasonal heat storages based on stable supercooling of a sodium acetate water mixture have been tested by means of experiments in a heat storage test facility. The modules had different volumes and designs. Further, different methods were used to transfer heat to and from the sodium acetate water mixture in the modules.

By means of the experiments:
- The heat exchange capacity rates to and from the sodium acetate water mixture in the heat storage modules were determined for different volume flow rates.
- The heat content of the heat storage modules were determined.
- The reliability of the supercooling was elucidated for the heat storage modules for different operation conditions.
- The reliability of a cooling method used to start solidification of the supercooled sodium acetate water mixture was elucidated. The method is making use of boiling CO2 in a small tank in good thermal contact with the outer surface of the heat storage module.
- Experience on operation of the heat storage modules was gained.

Based on the investigations recommendations for future development of a seasonal heat storage based on stable supercooling of a sodium acetate water mixture are given.

General information
State: Published
Organisations: Department of Civil Engineering, Section for Building Physics and Services
Authors: Furbo, S. (Intern), Fan, J. (Intern), Andersen, E. (Intern), Chen, Z. (Intern), Perers, B. (Intern)
Pages: 260-269
Publication date: 2012
Main Research Area: Technical/natural sciences

Publication information
Journal: Energy Procedia
Volume: 30
ISSN (Print): 1876-6102
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.44 SJR 0.495 SNIP 0.799
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.16 SJR 0.464 SNIP 0.598
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.359 SNIP 0.562 CiteScore 0.92
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.429 SNIP 0.807 CiteScore 1.09
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.42 SNIP 0.778 CiteScore 1.02
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
Scopus rating (2012): SJR 0.411 SNIP 0.55 CiteScore 1.08
ISI indexed (2012): ISI indexed no
Web of Science (2012): Indexed yes
Scopus rating (2011): SJR 0.877 SNIP 1.45 CiteScore 2.42
ISI indexed (2011): ISI indexed no
Scopus rating (2010): SJR 0.416 SNIP 0.91
Web of Science (2009): Indexed yes
Original language: English
PCM, Sodium acetate, Supercooling, Seasonal heat storage, Heat storage modules, Laboratory tests
DOIs: 10.1016/j.egypro.2012.11.031
Efficiencies of flat plate solar collectors at different flow rates

Two flat plate solar collectors for solar heating plants from Arcon Solvarme A/S are tested in a laboratory test facility for solar collectors at Technical University of Denmark (DTU). The collectors are designed in the same way. However, one collector is equipped with an ETFE foil between the absorber and the cover glass and the other is without ETFE foil. The efficiencies for the collectors are tested at different flow rates. On the basis of the measured efficiencies, the efficiencies for the collectors as functions of flow rate are obtained. The calculated efficiencies are in good agreement with the measured efficiencies.

Investigation of Thermal Performance of Flat Plate and Evacuated Tubular Solar Collectors According to a New Dynamic Test Method

A new dynamic test method is introduced. This so called improved transfer function method features on two new collector parameters. One is time term which can indicate solar collector's inner heat transfer ability and the other is a second order term of collector mean fluid temperature which can obtain fluid thermal capacitance in data processing. Then theoretical analysis and experimental verification are carried out to investigate influencing factors of obtaining accurate and stable second order term. A flat plate and ETC solar collector are compared using both the new dynamic method and a standard
method. The results show that the improved function method can accurately and robustly estimate these two kinds of solar collectors.

**General information**

**State:** Published  
**Organisations:** Department of Civil Engineering, Section for Building Physics and Services  
**Authors:** Kong, W. (Intern), Wang, Z. (Ekstern), Fan, J. (Intern), Perers, B. (Intern), Chen, Z. (Intern), Furbo, S. (Intern), Andersen, E. (Intern), Andreas Haberle (Ekstern)  
**Pages:** 152-161  
**Publication date:** 2012  
**Conference:** 1st International Conference on Solar Heating and Cooling for Buildings and Industry (SHC 2012), San Francisco, CA, United States, 09/07/2012 - 09/07/2012  
**Main Research Area:** Technical/natural sciences

**Publication information**

**Journal:** Energy Procedia  
**Volume:** 30  
**ISSN (Print):** 1876-6102  
**Ratings:**  
- BFI (2018): BFI-level 1  
- BFI (2017): BFI-level 1  
- Scopus rating (2017): CiteScore 1.44 SJR 0.495 SNIP 0.799  
- BFI (2016): BFI-level 1  
- Scopus rating (2016): CiteScore 1.16 SJR 0.464 SNIP 0.598  
- Web of Science (2016): Indexed yes  
- BFI (2015): BFI-level 1  
- Scopus rating (2015): SJR 0.359 SNIP 0.562 CiteScore 0.92  
- BFI (2014): BFI-level 1  
- Scopus rating (2014): SJR 0.429 SNIP 0.807 CiteScore 1.09  
- BFI (2013): BFI-level 1  
- Scopus rating (2013): SJR 0.42 SNIP 0.778 CiteScore 1.02  
- ISI indexed (2013): ISI indexed no  
- Web of Science (2013): Indexed yes  
- Scopus rating (2012): SJR 0.411 SNIP 0.55 CiteScore 1.08  
- ISI indexed (2012): ISI indexed no  
- Web of Science (2012): Indexed yes  
- Scopus rating (2011): SJR 0.877 SNIP 1.45 CiteScore 2.42  
- ISI indexed (2011): ISI indexed no  
- Scopus rating (2010): SJR 0.416 SNIP 0.91  
- Web of Science (2009): Indexed yes  
**Original language:** English  
**Solar collector parameters, Dynamic test method, Flat plate solar collector, ETC solar collector**  
**DOIs:**  
10.1016/j.egypro.2012.11.019  
**Source:** dtu  
**Source-ID:** n:oai:DTIC-ART:elsevier/377431999::25008  
**Publication:** Research - peer-review › Conference article – Annual report year: 2012

**Measurement and modelling of a multifunctional solar plus heat pump system from Nilan.: Experiences from one year of test operation.**

A multifunctional solar and heat pump unit from Nilan has been installed in the Performance Test Facility (PTF) at DTU Byg Denmark. It is part of the IEA Task 44 cooperation. Multifunctional means in this case: Hot water, Air heating, Ventilation, Air heat recovery, Air filtering and Floor heating. Nilan units, with additional air cooling and CO2 control, are also available.

The unit has been in operation for more than one year. The aim has been to stress the system operation to different conditions in the lab, to learn more about the performance, but also to find possible improvements especially concerning advanced control. The operation into extreme states of high hot water demand and low air ventilation rates, has also been done to develop and validate a TRNSYS system model. The model was developed and validated for the first period of operation mainly winter and early spring conditions. Now the system has been in operation during all seasons and a full year model could be developed and validated. The model also includes new possibilities for solar collector loop and heat pump operation control.
Model predictive control for a smart solar tank based on weather and consumption forecasts

In this work the heat dynamics of a storage tank were modelled on the basis of data and maximum likelihood methods. The resulting grey-box model was used for Economic Model Predictive Control (MPC) of the energy in the tank. The control objective was to balance the energy from a solar collector and the heat consumption in a residential house. The storage tank provides heat in periods where there is low solar radiation and stores heat when there is surplus solar heat. The forecasts of consumption patterns were based on data obtained from meters in a group of single-family houses in Denmark. The tank can also be heated by electric heating elements if necessary, but the electricity costs of operating these heating elements should be minimized. Consequently, the heating elements should be used in periods with cheap electricity. It is proposed to integrate a price-sensitive control to enable the storage tank to serve a smart energy system in which flexible consumers are expected to help balance fluctuating renewable energy sources like wind and solar. Through simulations, the impact of applying Economic MPC shows annual electricity cost savings up to 25-30%.

General information
State: Published
Organisations: Center for Energy Resources Engineering, Department of Informatics and Mathematical Modeling, Scientific Computing, Mathematical Statistics, Department of Civil Engineering, Section for Building Physics and Services
Authors: Halvgaard, R. (Intern), Bacher, P. (Intern), Perers, B. (Intern), Andersen, E. (Intern), Furbo, S. (Intern), Jørgensen, J. B. (Intern), Poulsen, N. K. (Intern), Madsen, H. (Intern)
Pages: 270-278
Publication date: 2012
Main Research Area: Technical/natural sciences

Publication information
Journal: Energy Procedia
Volume: 30
ISSN (Print): 1876-6102
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.44 SJR 0.495 SNIP 0.799
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.16 SJR 0.464 SNIP 0.598
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.359 SNIP 0.562 CiteScore 0.92
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.429 SNIP 0.807 CiteScore 1.09
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.42 SNIP 0.778 CiteScore 1.02
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
Scopus rating (2012): SJR 0.411 SNIP 0.55 CiteScore 1.08
ISI indexed (2012): ISI indexed no
Web of Science (2012): Indexed yes
Scopus rating (2011): SJR 0.877 SNIP 1.45 CiteScore 2.42
Thermal behavior of a heat exchanger module for seasonal heat storage

Experimental and theoretic investigations are carried out to study the heat transfer capacity rate of a heat exchanger module for seasonal heat storage with sodium acetate trihydrate (SAT) supercooling in a stable way. A sandwich heat storage test module has been built with the phase change material (PCM) storage box in between two plate heat exchangers. Charge of the PCM storage is investigated experimentally with solid phase SAT as initial condition. Discharge of the PCM storage with the presence of crystallization is studied experimentally. Fluid flow and heat transfer in the PCM module are theoretically investigated by Computational Fluid Dynamics (CFD) calculations. The heat transfer rates between the PCM storage and the heating fluid/cooling fluid in the plate heat exchangers are determined. The CFD calculated temperatures are compared to measured temperatures. Based on the studies, recommendations on how best to transfer heat to and from the seasonal heat storage module are given.

General information
State: Published
Organisations: Department of Civil Engineering, Section for Building Physics and Services
Authors: Fan, J. (Intern), Furbo, S. (Intern), Andersen, E. (Intern), Chen, Z. (Intern), Perers, B. (Intern), Dannemand, M. (Intern)
Pages: 244-254
Publication date: 2012
Main Research Area: Technical/natural sciences

Publication information
Journal: Energy Procedia
Volume: 30
ISSN (Print): 1876-6102
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.44 SJR 0.495 SNIP 0.799
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.16 SJR 0.464 SNIP 0.598
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.359 SNIP 0.562 CiteScore 0.92
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.429 SNIP 0.807 CiteScore 1.09
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.42 SNIP 0.778 CiteScore 1.02
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
Scopus rating (2012): SJR 0.411 SNIP 0.55 CiteScore 1.08
ISI indexed (2012): ISI indexed no
Web of Science (2012): Indexed yes
Scopus rating (2011): SJR 0.877 SNIP 1.45 CiteScore 2.42
ISI indexed (2011): ISI indexed no
Scopus rating (2010): SJR 0.416 SNIP 0.91
Web of Science (2009): Indexed yes
Thermal performance of marketed SDHW systems under laboratory conditions

A test facility for solar domestic hot water systems, SDHW systems, was established at the Technical University of Denmark in 1992. During the period 1992-2012, 21 marketed SDHW systems, 16 systems from Danish manufacturers and 5 systems from manufacturers from abroad, have been tested in the test facility under the same realistic test conditions. The systems had different designs and sizes. Each system was tested during a long test period consisting of both a summer and winter period.

Detailed simulation models for each system were developed. The simulation models were modified and the input to the models were fitted in such a way, that the calculated thermal performance is in good agreement with the measured thermal performance, both for a typical winter period and for a typical summer period. In this way it is possible to use the simulation models to calculate the yearly thermal performance of the tested systems with weather data from the Danish Test Reference Year and with the same hot water consumption.

The tests showed that the designs of the heat storage and that the system concepts are of vital importance for the thermal performances of the systems and that neither the solar collector efficiency nor the solar collector area is influencing the thermal performance as much as the heat storage design and the system concept. The tests also showed that all the tested systems can be improved with relative simple design changes.

Based on the tests it is concluded that high thermal performances of SDHW systems are achieved by reducing the heat loss from the upper part of the heat stores to a minimum by having no pipes connected to the upper part of the tank, reducing the auxiliary volume at the top of the heat stores as much as possible, of course with consideration of the required hot water comfort, avoiding simple errors, using the low flow principle and heat stores with a high degree of thermal stratification and by using components with good thermal characteristics.

General information
State: Published
Organisations: Department of Civil Engineering, Section for Building Physics and Services
Authors: Furbo, S. (Intern), Andersen, E. (Intern), Fan, J. (Intern), Chen, Z. (Intern), Perers, B. (Intern)
Number of pages: 8
Publication date: 2012
Main Research Area: Technical/natural sciences

Afprøvning af energisolfanger med luftsolfangerfunktion fra Venetian Solar ApS

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Andersen, E. (Intern)
Publication date: 2011

Publication information
Place of publication: Kgs. Lyngby
Publisher: DTU Byg, Danmarks Tekniske Universitet
Original language: English

Series: DTU Byg Sagsrapport
Number: SR 11-10 (DK)
ISSN: 1601-8605
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 317161
Publication: Research › Report – Annual report year: 2011
Energy savings for solar heating systems in one family houses

**General information**
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Furbo, S. (Intern), Fan, J. (Intern), Andersen, E. (Intern), Perers, B. (Intern)
Publication date: 2011

**Host publication information**
Title of host publication: ISES Solar World Congress 2011 Proceedings
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 317027
Publication: Research - peer-review › Article in proceedings – Annual report year: 2011

Experimental studies on seasonal heat storage based on stable supercooling of a sodium acetate water mixture

Laboratory tests of a 230 l seasonal heat storage module with a sodium acetate water mixture have been carried out. The aim of the tests is to elucidate how best to design a seasonal heat storage based on the salt water mixture, which supercools in a stable way. The module can be a part of a seasonal heat storage, that will be suitable for solar heating systems which can fully cover the yearly heat demand of Danish low energy buildings. The tested module has approximately the dimensions 2020 mm x 1285 mm x 80 mm. The module material is steel and the wall thickness is 2 mm. Different methods to transfer heat to and from the module have been tested. Further, a solidification start method, based on a strong cooling of a small part of the salt water mixture in the module by boiling CO2 in a small brass tank in good thermal contact to the outer side of the module wall, has been tested. Tests of the long term durability of small scale seasonal heat storage modules with different heights have been carried out in order to elucidate the maximum height of a module resulting in a stable heat storage. Based on the studies, recommendations for the design of a seasonal heat storage based on modules with a sodium acetate water mixture will be given.

**General information**
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Furbo, S. (Intern), Dragsted, J. (Intern), Fan, J. (Intern), Andersen, E. (Intern), Perers, B. (Intern)
Publication date: 2011

**Host publication information**
Title of host publication: ISES Solar World Congress 2011 Proceedings
ISBN (Print): 978-3-9814659-0-7
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 317022
Publication: Research - peer-review › Article in proceedings – Annual report year: 2011

Heat transfer capacity of a heat exchanger module for seasonal heat storage

**General information**
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Fan, J. (Intern), Furbo, S. (Intern), Chen, Z. (Intern), Andersen, E. (Intern), Perers, B. (Intern)
Publication date: 2011

**Host publication information**
Title of host publication: ISES Solar World Congress 2011 Proceedings
ISBN (Print): 978-3-9814659-0-7
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 317007
Publication: Research - peer-review › Article in proceedings – Annual report year: 2011
Modelling, Measurements and Validation of a solar plus heat pump compact unit from Nilan

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering, Technical University of Denmark
Authors: Perers, B. (Intern), Andersen, E. (Intern), Furbo, S. (Intern), Tsouvalas, A. (Ekstern)
Publication date: 2011

Host publication information
Title of host publication: Proceedings of the fifth European Solar Thermal Energy Conference
Main Research Area: Technical/natural sciences
Conference: European Solar Thermal Energy Conference, Marseille, France, 01/01/2011
Source: orbit
Source-ID: 317130
Publication: Research - peer-review › Article in proceedings – Annual report year: 2011

Prøvestand til luftsolfangere

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Andersen, E. (Intern)
Number of pages: 17
Publication date: 2011

Publication information
Place of publication: Kgs. Lyngby
Publisher: DTU Byg, Danmarks Tekniske Universitet
ISBN (Print): 9788778773371
Original language: English

Series: DTU Byg Rapport
Number: R 255 (DK)
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 317162
Publication: Research › Report – Annual report year: 2011

Solar combisystems with forecast control to increase the solar fraction and lower the auxiliary energy cost
Solar Combi systems still need quite a lot of auxiliary energy especially in small systems without seasonal storage possibilities. The control of the auxiliary energy input both in time and power is important to utilize as much as possible of the solar energy available from the collectors and also to use low backup energy prices during the day if electricity is used. The storage function and both stratified charging and extraction of heat, are very important, to separate different temperature zones in the storage. This paper describes a step towards forecast control for electricity based auxiliary energy sources. It can be either direct electric heating elements or a heat pump upgrading ambient energy in the air, ground, solar collector or waste heat from the house. The paper describes system modeling and simulation results. Advanced laboratory experiments are also starting now with three different combisystems, operating in parallel. These systems will be briefly described too.

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Perers, B. (Intern), Furbo, S. (Intern), Fan, J. (Intern), Andersen, E. (Intern), Chen, Z. (Intern)
Publication date: 2011

Host publication information
Title of host publication: ISES Solar World Congress 2011 Proceedings
ISBN (Print): 978-3-9814659-0-7
Main Research Area: Technical/natural sciences
Links:
http://www.swc2011.org/cms/
Study on a tracking solar collector

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Chen, Z. (Intern), Furbo, S. (Intern), Fan, J. (Intern), Andersen, E. (Intern), Perers, B. (Intern)
Publication date: 2011

Host publication information
Title of host publication: Proceedings of the ISES Solar World Congress 2011
ISBN (Print): 978-3-9814659-0-7
Main Research Area: Technical/natural sciences
Links:
http://www.swc2011.org/cms/
Source: orbit
Source-ID: 316688
Publication: Research - peer-review › Article in proceedings – Annual report year: 2011

Thermal performance of small SDHW systems with differently designed mantle tanks

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Furbo, S. (Intern), Andersen, E. (Intern)
Publication date: 2011

Publication information
Place of publication: Kgs. Lyngby
Publisher: Technical University of Denmark, Department of Civil Engineering
Original language: English
Series: DTU Civil Engineering Reports
Number: SR-11 06
ISSN: 1601-8605
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 316920
Publication: Research - peer-review › Report – Annual report year: 2011

Thermal stratification in hot water storage tanks with fabric stratification inlet pipes

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Andersen, E. (Intern), Furbo, S. (Intern), Chen, Z. (Intern)
Publication date: 2011

Host publication information
Title of host publication: ISES Solar World Congress 2011 Proceedings
ISBN (Print): 978-3-9814659-0-7
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 317034
Publication: Research - peer-review › Article in proceedings – Annual report year: 2011

A method to determine stratification efficiency of thermal energy storage processes independently from storage heat losses
A new method for the calculation of a stratification efficiency of thermal energy storages based on the second law of thermodynamics is presented. The biasing influence of heat losses is studied theoretically and experimentally. Theoretically, it does not make a difference if the stratification efficiency is calculated based on entropy balances or based on exergy balances. In practice, however, exergy balances are less affected by measurement uncertainties, whereas entropy balances cannot be recommended if measurement uncertainties are not corrected in a way that the energy balance of the storage process is in agreement with the first law of thermodynamics. A comparison of the stratification efficiencies obtained from experimental results of charging, standby, and discharging processes gives meaningful insights into the different mixing behaviors of a storage tank that is charged and discharged directly, and a tank-in-tank system whose outer tank is charged and the inner tank is discharged thereafter. The new method has a great potential for the comparison of the stratification efficiencies of thermal energy storages and storage components such as stratifying devices.
DETAILED MODELLING OF CHARGING BEHAVIOUR OF SMART SOLAR TANKS

The charging behaviour of smart solar tanks for solar combisystems for one-family houses is investigated with detailed Computational Fluid Dynamics (CFD) modelling and Particle Image Velocimetry (PIV) measurements. The smart solar tank can be charged with a variable auxiliary volume fitted to the expected future energy demand. Therefore the heat loss from the tank is decreased and the thermal performance of the solar heating system is increased compared to a traditional system with a fixed auxiliary volume. The solar tank can be charged either by an electric heating element situated in the tank or by an electric heating element in a side-arm mounted on the side of the tank. Detailed CFD models of the smart tanks are built with different mesh densities in the tank and in the side-arm. The thermal conditions of the tank during charging are calculated with the CFD models. The fluid flow and temperature calculations are compared to PIV (Particle Image Velocimetry) measurements of fluid flows and temperature measurements. The aim is to elucidate the temperature distribution and thermal stratification of the tank during charging. It is elucidated how the calculated temperatures in the tank are influenced by the mesh densities, the distribution of computational cells, the physical model and time steps used in the simulations. The findings of the investigations will be used as guidance for creation of CFD models for optimal design of smart solar tanks.

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Fan, J. (Intern), Andersen, E. (Intern), Furbo, S. (Intern), Perers, B. (Intern)
Publication date: 2010
Event: Poster session presented at International Conference on Solar Heating, Cooling and Buildings, Graz, Austria.
Main Research Area: Technical/natural sciences
Smart Solar Tanks, Computational Fluid Dynamics, Particle Image Velocimetry, Charging Behaviour
Electronic versions:
posterCFDSmartSolarTank.pdf
Source: orbit
Source-ID: 272332
Publication: Research - peer-review › Poster – Annual report year: 2010

DETAILED MODELLING OF CHARGING BEHAVIOUR OF SMART SOLAR TANKS

The charging behaviour of smart solar tanks for solar combisystems for one-family houses is investigated with detailed Computational Fluid Dynamics (CFD) modelling and Particle Image Velocimetry (PIV) measurements. The smart solar tank can be charged with a variable auxiliary volume fitted to the expected future energy demand. Therefore the heat loss
from the tank is decreased and the thermal performance of the solar heating system is increased compared to a traditional system with a fixed auxiliary volume. The solar tank can be charged either by an electric heating element situated in the tank or by an electric heating element in a side-arm mounted on the side of the tank. Detailed CFD models of the smart tanks are built with different mesh densities in the tank and in the side-arm. The thermal conditions of the tank during charging are calculated with the CFD models. The fluid flow and temperature calculations are compared to PIV (Particle Image Velocimetry) measurements of fluid flows and temperature measurements. The aim is to elucidate the temperature distribution and thermal stratification of the tank during charging. It is elucidated how the calculated temperatures in the tank are influenced by the mesh densities, the distribution of computational cells, the physical model and time steps used in the simulations. The findings of the investigations will be used as guidance for creation of CFD models for optimal design of smart solar tanks.

**General information**
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Fan, J. (Intern), Andersen, E. (Intern), Furbo, S. (Intern), Perers, B. (Intern)
Publication date: 2010

**Host publication information**
Title of host publication: Proceedings of EuroSun 2010: International Conference on Solar Heating, Coolings and Buildings
ISBN (Print): 978-3-901425-13-4
Main Research Area: Technical/natural sciences

**Solar Electric heating systems using smart solar tanks and variable electricity costs**

**General information**
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Perers, B. (Intern), Furbo, S. (Intern), Andersen, E. (Intern), Fan, J. (Intern)
Publication date: 2010

**Host publication information**
Title of host publication: Eurosun 2010
ISBN (Print): 978-3-901425-13-4
Main Research Area: Technical/natural sciences
The covariation of heating load and solar energy production with the electricity price variations in Denmark

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering, Technical University of Denmark
Authors: Perers, B. (Intern), Furbo, S. (Intern), Andersen, E. (Intern), Fan, J. (Ekstern)
Publication date: 2010

Host publication information
Title of host publication: EuroSun 2010. Book of proceedings
ISBN (Print): 978-3-901425-13-4
Main Research Area: Technical/natural sciences
Source-ID: 273706
Publication: Research - peer-review › Article in proceedings – Annual report year: 2010

Thermal advantage of tracking solar collectors under Danish weather conditions
Theoretical investigations have been carried out with the aim to elucidate the thermal advantage of tracking solar collectors for different weather conditions in Kgs. Lyngby, Denmark (55.8°N), and for the weather conditions in Sisimiut, Greenland (66.9°N), just north of the arctic circle. The investigations are based on calculations with a newly developed program. Measured weather data from a solar radiation measurement station at Technical University of Denmark in Kgs. Lyngby Denmark in the period 1990 to 2002 and the Danish Design Reference Year, DRY data file are used in the investigations. The weather data used for Sisimiut are based on a Test Reference Year, TRY weather data file. The thermal advantages of different tracking strategies is investigated for two flat plate solar collectors with different efficiencies, operated at different temperature levels. The investigations show that the advantage of full tracking is in the range 40% – 90% depending on the solar collector and the operation conditions. The advantage is higher for a low efficient solar collector than for a high efficient solar collector and higher for high solar collector temperatures than for low solar collector temperatures. Further, design reference years are not suitable to elucidate the advantage by tracking.

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Andersen, E. (Intern), Dragsted, J. (Intern), Furbo, S. (Intern), Perers, B. (Intern), Fan, J. (Intern)
Publication date: 2010

Host publication information
Title of host publication: Thermal advantage of tracking solar collectors under Danish weather conditions
Place of publication: Graz, Austria
ISBN (Print): 978-3-901425-13-4
Main Research Area: Technical/natural sciences
Source-ID: 272468
Publication: Research - peer-review › Article in proceedings – Annual report year: 2010

Towards seasonal heat storage based on stable super cooling of sodium acetate trihydrate

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Furbo, S. (Intern), Dragsted, J. (Intern), Chen, Z. (Intern), Fan, J. (Intern), Andersen, E. (Intern), Perers, B. (Intern)
Publication date: 2010

Host publication information
Title of host publication: EuroSun 2010 Congress Proceedings
Main Research Area: Technical/natural sciences
Source-ID: 272401
Publication: Research - peer-review › Article in proceedings – Annual report year: 2010
Comparative analysis of thermal energy storage stratification efficiency: A new method combines advantages of previous approaches

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering, Graz University of Technology
Authors: Haller, M. (Ekstern), Streicher, W. (Ekstern), Andersen, E. (Intern), Furbo, S. (Intern)
Publication date: 2009

Host publication information
Title of host publication: EffStock 2009 Proceedings
Main Research Area: Technical/natural sciences
Conference: EffStock 2009 Proceedings, 01/01/2009
Source: orbit
Source-ID: 255028
Publication: Research - peer-review › Article in proceedings – Annual report year: 2009

Methods to determine stratification efficiency of thermal energy storage processes—Review and theoretical comparison

This paper reviews different methods that have been proposed to characterize thermal stratification in energy storages from a theoretical point of view. Specifically, this paper focuses on the methods that can be used to determine the ability of a storage to promote and maintain stratification during charging, storing and discharging, and represent this ability with a single numerical value in terms of a stratification efficiency for a given experiment or under given boundary conditions. Existing methods for calculating stratification efficiencies have been applied to hypothetical storage processes of charging, discharging and storing, and compared with the rate of entropy production caused by mixing calculated for the same experiments. The results depict that only one of the applied methods is in qualitative agreement with the rate of entropy production, however, none of the applied methods is in agreement with the rate of entropy production and also able to distinguish between the entropy production caused by mixing and the entropy changes due to heat losses.

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering, Graz University of Technology, Queen's University Kingston
Authors: Haller, M. (Ekstern), Cruickshank, C. (Ekstern), Streicher, W. (Ekstern), Harrison, S. J. (Ekstern), Andersen, E. (Intern), Furbo, S. (Intern)
Pages: 1847-1860
Publication date: 2009
Main Research Area: Technical/natural sciences

Publication information
Journal: Solar Energy
Volume: 83
Issue number: 10
ISSN (Print): 0038-092X
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 4.89 SJR 1.615 SNIP 1.791
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 4.52 SJR 1.504 SNIP 1.746
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.912 SNIP 2.085 CiteScore 4.61
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.962 SNIP 2.671 CiteScore 4.77
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.99 SNIP 2.85 CiteScore 4.44
Theoretical variations of the thermal performance of different solar collectors and solar combi systems as function of the varying yearly weather conditions in Denmark

The thermal performances of solar collectors and solar combi systems with different solar fractions are studied under the influence of the Danish Design Reference Year, DRY data file, and measured weather data from a solar radiation measurement station situated at the Technical University of Denmark in Kgs. Lyngby. The data from DRY data file are used for any location in Denmark. The thermal performances of the solar heating systems are calculated by means of validated computer models. The measured yearly solar radiation varies by approximately 23% in the period from 1990 until 2002, and the investigations show that it is not possible to predict the yearly solar radiation on a tilted surface based on the yearly global radiation. The annual thermal performance of solar combi systems cannot with reasonable approximation be fitted to a linear function of the annual total radiation on the solar collector or the annual global radiation. Solar combi systems with high efficient solar collectors are more influenced by weather variations from one year to another than systems with low efficient solar collectors. The annual thermal performance of solar collectors cannot be predicted from the global radiation, but both the annual thermal performance and the annual utilized solar energy can with a reasonable approximation be fitted to a linear function of the yearly solar radiation on the collector for both flat plate and evacuated tubular solar collectors. Also evacuated tubular solar collectors utilize less sunny years with large parts of diffuse radiation relatively better than flat plate collectors.

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Andersen, E. (Intern), Furbo, S. (Intern)
Pages: 552-565
Publication date: 2009
Main Research Area: Technical/natural sciences

Publication information
Journal: Solar Energy
Volume: 83
Issue number: 4
ISSN (Print): 0038-092X
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 4.89 SJR 1.615 SNIP 1.791
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 4.52 SJR 1.504 SNIP 1.746
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.912 SNIP 2.085 CiteScore 4.61
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.962 SNIP 2.671 CiteScore 4.77
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.99 SNIP 2.85 CiteScore 4.44
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.605 SNIP 2.517 CiteScore 3.65
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.283 SNIP 2.178 CiteScore 3.19
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.369 SNIP 2.16
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.265 SNIP 2.158
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.684 SNIP 1.994
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.685 SNIP 2.085
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.594 SNIP 2.229
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.233 SNIP 1.601
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 0.523 SNIP 1.702
Scopus rating (2003): SJR 1.152 SNIP 1.423
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 1.331 SNIP 1.561
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 1.292 SNIP 1.277
Scopus rating (2000): SJR 0.77 SNIP 1.065
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 0.688 SNIP 1.253
Original language: English
solar collectors, utilized part of solar radiation, thermal performance, solar heating systems, solar radiation variations,
Measured weather data
DOIs:
10.1016/j.solener.2008.10.009
Source: orbit
Source-ID: 224202
Publication: Research - peer-review › Journal article – Annual report year: 2009

Udvikling af fremtidssikret solvarmeanlæg

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Furbo, S. (Intern), Andersen, E. (Intern)
Pages: 40-43
Publication date: 2009
Main Research Area: Technical/natural sciences

Publication information
Journal: H V A C Magasinet
Volume: 3
ISSN (Print): 1603-6913
Ratings:
ISI indexed (2013): ISI indexed no
ISI indexed (2012): ISI indexed no
ISI indexed (2011): ISI indexed no
Original language: Danish
Source: orbit
Source-ID: 255032
Publication: Communication › Journal article – Annual report year: 2009

Advanced storage concepts for solar and low energy buildings: IEA Task 32 final report
Heat storage for solar heating systems - now and in the future

General information
State: Published
Organisations: Department of Civil Engineering, Section for Building Physics and Services
Authors: Furbo, S. (Intern), Andersen, E. (Intern)
Publication date: 2008
Conference: Conference on Thermal Storage, Prague, Czech Republic, 01/01/2008
Main Research Area: Technical/natural sciences

Publication information
Publisher: Proceedings of Conference on Thermal Storage, Prague, Czech Republic
Original language: English
Source: orbit
Source-ID: 233013
Publication: Research - peer-review › Conference article – Annual report year: 2008

Inlet stratifiers

General information
State: Published
Organisations: Department of Civil Engineering
Authors: Andersen, E. (Intern)
Publication date: 2008

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 232534
Publication: Research › Sound/Visual production (digital) – Annual report year: 2008

Investigation of solar radiation models for high northern latitudes

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Dragsted, J. (Intern), Furbo, S. (Intern), Andersen, E. (Intern)
Publication date: 2008

Host publication information
Title of host publication: Bæredygtig energiforsyning i Arktis : sol, vind, vand mm.
Main Research Area: Technical/natural sciences
Conference: Bæredygtig energiforsyning i Arktis, Sisimiut, Greenland, 01/01/2008
Source: orbit
Investigations on stratification devices for hot water stores

The significance of the thermal stratification for the energy efficiency of small solar-thermal hot water heat stores is pointed out. Exemplary the thermal stratification build-up with devices already marketed as well as with devices still in development has been investigated experimentally and theoretically, taking into account different realistic operation conditions. The methods (selective temperature measurement, non-invasive field measuring methods PIV and LIF, Computational Fluid Dynamics (CFD)) suitable for the experimental and theoretical analysis of thermal stratification devices are introduced.
Long time durability tests of fabric inlet stratification pipes

The long time durability of seven different two layer fabric inlet stratification pipes for enhancing thermal stratification in hot water stores is investigated experimentally. Accelerated durability tests are carried out with the inlet stratification pipes both in a domestic hot water tank and in a space heating tank. Heating/cooling cycles are carried out with different operation conditions including different temperature levels and volume flow rates. The results show that that lime contained in the domestic water is deposited in the fabric pipes in the domestic hot water tank and that this destroys the capability of building up thermal stratification for the fabric inlet stratification pipe. The results also show that although dirt, algae etc. are deposited in the fabric pipes in the space heating tank, the capability of the fabric inlet stratifiers to build up thermal stratification is unchanged for five out of seven fabric pipes within the test period.

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Andersen, E. (Intern), Furbo, S. (Intern)
Publication date: 2008
Stratification devices
Thermal stratification in the storage tank is extremely important in order to achieve high thermal performance of a solar heating system. High temperatures in the top of the storage tank and low temperatures in the bottom of the storage tank lead to the best operation conditions for any solar heating system. High temperatures in the top of the storage tank established by the energy from the solar collector reduce the use of auxiliary energy. Low temperatures in the bottom of the storage tank improve the operation conditions for the solar collector. Using thermal stratified heat storages results in longer operation periods and improved utilization of the solar collector. Thermal stratification can be achieved, for example by using inlet stratification devices at all inlets to the storage tank. This paper presents how thermal stratification is established and utilized by means of inlet stratifiers. A new multi layer fabric stratification pipe is presented together with marketed stratification pipes.

General information
State: Published
Organisations: Department of Civil Engineering, Section for Building Physics and Services
Authors: Andersen, E. (Intern), Furbo, S. (Intern)
Publication date: 2008

Host publication information
Title of host publication: Konference on thermal storage
Place of publication: Rozvojova 135, 165 02 Prague 6
Editor: Kudrnova, E.
Main Research Area: Technical/natural sciences
Conference: Conference on thermal energy storage, Technology Centre of the Academy of Sciences of the Czech Republic, 01/01/2008
thermal storage, stratification, fabric stratifier
Source: orbit
Source-ID: 224205
Publication: Research › Article in proceedings – Annual report year: 2008

Solar combi systems
The focus in the present Ph.D. thesis is on the active use of solar energy for domestic hot water and space heating in so-called solar combi systems. Most efforts have been put into detailed investigations on the design of solar combi systems and on devices used for building up thermal stratification in hot water storage tanks. A new stratification device has been developed and patented. The device is a two fabric layer stratification inlet pipe. The strategy used in the thesis is a combination of experimental and theoretical investigations. The experimental investigations are used to study the thermal behaviour of different components, and the theoretical investigations are used to study the influence of the thermal behaviour on the yearly thermal performance of solar combi systems. The experimental investigations imply detailed temperature measurements and flow visualization with the Particle Image Velocimetry measurement method. The theoretical investigations are based on the transient simulation program TrnSys and Computational Fluid Dynamics. The Ph.D. thesis demonstrates the influence on the thermal performance of solar combi systems of a number of different parameters such as the varying weather conditions in Denmark, the domestic hot water consumption, the space heating demand and the size of the space heating system etc. through a detailed parameter sensitivity analysis. Further the calculations show that high thermal performances of solar heating systems are achieved by highly thermal stratified heat storages. Furthermore, it is demonstrated that thermal stratification can be build up in a nearly perfect way by using stratification devices. Different operation conditions were applied in the experiments that showed that different stratification devices are suitable for different operation conditions. Tests, simulating both the thermal behaviour of a stratifier in a solar collector loop and in a space heating loop, have been carried out. The thermal behaviour of the stratifiers is demonstrated both with forced flow rates in the range from 2 – 10 l/min and with a volume flow rate based on thermosyphoning, the latter with both an external plate heat exchanger and with an imerged heat exchanger spiral.

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Andersen, E. (Intern), Furbo, S. (Intern)
Publication date: Aug 2007

Publication information
ISBN (Print): 9788778772282
Original language: English
Series: BYG Rapport
Number: R-156
Main Research Area: Technical/natural sciences
Electronic versions: byg-r156.pdf
Heat losses from pipes connected to hot water storage tanks

General information
State: Published
Organisations: Department of Civil Engineering
Authors: Andersen, E. (Intern)
Publication date: 2007

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 232535
Publication: Research › Sound/Visual production (digital) – Annual report year: 2007

Heat losses through pipe connections in hot water stores
The heat loss from pipe connections at the top of hot water storage tanks with and without a heat trap is investigated theoretically and compared to similar experimental investigations. Computational Fluid Dynamics (CFD) is used for the theoretical analysis. The investigations show that the heat loss from an ideally insulated pipe connected to the top of a hot water tank is mainly due to a natural convection flow in the pipe, that the heat loss coefficient of pipes connected to the top of a hot water tank is high, and that a heat trap can reduce the heat loss coefficient significantly. Further, calculations show that the yearly thermal performance of solar domestic hot water systems is strongly reduced if the hot water tank has a thermal bridge located at the top of the tank.

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Andersen, E. (Intern), Fan, J. (Intern), Furbo, S. (Intern)
Pages: 1998-2002
Publication date: 2007

Host publication information
Title of host publication: Proceedings of ISES 2007 : Solar Energy and Human Settlement
Volume: Volume IV
Place of publication: Beijing, China
Publisher: Springer
ISBN (Print): 978-7-302-16146-2
Main Research Area: Technical/natural sciences
Hot water stores, pipe connection, thermal bridge, heat loss, heat trap, measurements, CFD-calculations
Source: orbit
Source-ID: 193855
Publication: Research - peer-review › Article in proceedings – Annual report year: 2007

Long time durability tests of fabric inlet stratifiers and calculations with T32 reference conditions

General information
State: Published
Organisations: Department of Civil Engineering
Authors: Andersen, E. (Intern)
Publication date: 2007

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 208525
Publication: Research › Sound/Visual production (digital) – Annual report year: 2007
Multilayer fabric stratification pipes for solar tanks

The thermal performance of solar heating systems is strongly influenced by the thermal stratification in the heat storage. The higher the degree of thermal stratification is, the higher the thermal performance of the solar heating systems. Thermal stratification in water storages can for instance be achieved by use of inlet stratifiers combined with low flow operation in the solar collector loop. In this paper, investigations of a number of different fabric stratification pipes are presented and compared to a non flexible inlet stratifier. Additional, detailed investigations of the flow structure close to two fabric stratification pipes are presented for one set of operating conditions by means of the optical PIV (Particle Image Velocimetry) method.
Theoretical comparison of solar combi systems and stratification design options with T32 reference conditions

General information
State: Published
Organisations: Department of Civil Engineering
Authors: Andersen, E. (Intern)
Publication date: 2007

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 193857
Publication: Research - peer-review › Journal article – Annual report year: 2007

Theoretical comparison of solar water/space-heating combi systems and stratification design options

A theoretical analysis of differently designed solar combi systems is performed with weather data from the Danish Design Reference Year (55°N). Three solar combi system designs found on the market are investigated. The investigation focuses on the influence of stratification on the thermal performance under different operation conditions with different domestic hot water and space heating demands. The solar combi systems are initially equipped with heat exchanger spirals and direct inlets to the tank. A step-by-step investigation is performed demonstrating the influence on the thermal performance of using inlet stratification pipes at the different inlets. Also, it is investigated how the design of the space
heating system, the control system of the solar collectors, and the system size influence the thermal performance of solar combi systems. The work is carried out within the Solar Heating and Cooling Programme of the International Energy Agency (IEA SHC), Task 32.

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Andersen, E. (Intern), Furbo, S. (Intern)
Pages: 438-448
Publication date: 2007
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Solar Energy Engineering
Volume: 129
ISSN (Print): 0199-6231
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): SNIP 0.891 SJR 0.615 CiteScore 1.61
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.37 SJR 0.57 SNIP 0.881
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.879 SNIP 1.272 CiteScore 1.65
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.801 SNIP 1.351 CiteScore 1.75
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.737 SNIP 1.54 CiteScore 1.35
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.582 SNIP 1.1 CiteScore 1.08
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.472 SNIP 1.263 CiteScore 1.01
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.536 SNIP 1.257
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.649 SNIP 1.111
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.668 SNIP 1.071
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.516 SNIP 1.018
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.151 SNIP 1.424
Scopus rating (2005): SJR 1.128 SNIP 1.16
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 0.568 SNIP 1.624
Theoretical investigations of solar combi systems

General information
State: Published
Organisations: Department of Civil Engineering
Authors: Andersen, E. (Intern)
Publication date: 2007
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 208522
Publication: Research - peer-review › Paper – Annual report year: 2007

Towards new standards for advanced stores: Final report

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering, SPF, Rapperswil, Switzerland
Authors: Furbo, S. (Intern), Andersen, E. (Intern), Vogelsanger, P. (Ekstern)
Publication date: 2007

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Electronic versions:
Simon Furbo.pdf
Source: orbit
Source-ID: 209879
Publication: Research - peer-review › Report – Annual report year: 2007

Advanced storage concepts for solar thermal systems in low energy buildings. Slutrapport

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Furbo, S. (Intern), Andersen, E. (Intern), Schultz, J. M. (Intern)
Publication date: 2006

Publication information
Publisher: DTU Byg, Danmarks Tekniske Universitet
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 193579
Design of medium sized solar combi systems

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Andersen, E. (Intern)
Publication date: 2006

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 195119
Publication: Research › Sound/Visual production (digital) – Annual report year: 2006

Fabric inlet stratifiers for advanced water stores

General information
State: Published
Organisations: Department of Civil Engineering, Section for Building Physics and Services
Authors: Andersen, E. (Intern)
Publication date: 2006
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 193858
Publication: Research › Paper – Annual report year: 2006

Fabric inlet stratifiers for solar tanks with different volume flow rate

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Andersen, E. (Intern)
Publication date: 2006

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 195118
Publication: Research › Sound/Visual production (digital) – Annual report year: 2006

Fabric inlet stratifiers for solar tanks with different volume flow rates
In this paper investigations of two different two layer fabric stratification pipes are presented and compared to a rigid stratification pipe with holes with "non-return" valves. The fabric stratification pipes are constructed of filament polyester and acrylic. The fabric pipes are mounted in the centre of a glass tank (400 x 400 x 900 mm). The forced volume flow rate is in the range of 6 – 10 l/min, and water enters the stratification pipe from the bottom of the tank. The thermal behaviour of the stratification pipes is investigated for different realistic operation conditions

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Andersen, E. (Intern), Furbo, S. (Intern)
Publication date: 2006

Host publication information
Title of host publication: Proceedings of Eurosun 2006
Main Research Area: Technical/natural sciences
Solar tanks, Thermal stratification, Inlet stratification pipes
Source: orbit
Source-ID: 193854
Publication: Research - peer-review › Article in proceedings – Annual report year: 2006

**Fabric inlet stratifiers for solar tanks with different volume flow rates**

*General information*
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Andersen, E. (Intern)
Publication date: 2006

*Publication information*
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 195121
Publication: Research › Sound/Visual production (digital) – Annual report year: 2006

**Fabric stratification devices-Multilayer fabric stratifier**

*General information*
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Andersen, E. (Intern)
Publication date: 2006

*Publication information*
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 194168
Publication: Research › Sound/Visual production (digital) – Annual report year: 2006

**Fyrtånsbygd - 083 Sarfannguaq: Forprojekt**

*General information*
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering, Fluid Mechanics, Department of Mechanical Engineering, Electric Power Engineering, Department of Electrical Engineering, Section for Geotechnics and Geology, Arctic Technology Centre, Nukissiorfiit
Authors: Andersen, E. (Intern), Furbo, S. (Intern), Hansen, K. S. (Intern), Hansen, M. O. L. (Intern), Kjeldmann, P. (Ekstern), Larsen, E. (Intern), Nielsen, M. H. (Intern), Villumsen, A. (Intern)
Number of pages: 82
Publication date: 2006

*Publication information*
Place of publication: Lyngby
Publisher: Technical University of Denmark (DTU)
Original language: Danish
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 195052
Publication: Research › Report – Annual report year: 2006

**INLET STRATIFICATION DEVICE**

An inlet stratification device (5) for a circuit circulating a fluid through a tank (1) and for providing and maintaining stratification of the fluid in the tank (1). The stratification device (5) is arranged vertically in the tank (1) and comprises an inlet pipe (6) being at least partially formed of a flexible porous material and having an inlet (19) and outlets formed of the pores of the porous material. The stratification device (5) further comprises at least one outer pipe (7) surrounding the inlet pipe (6) in spaced relationship thereto and being at least partially formed of a porous material.
Investigations of medium sized solar combi systems

A large variety of solar combi systems are on the market, but it is still too early to draw conclusions on optimum design of solar combi systems. Among others, the following questions need to be answered: Is an external domestic hot water preparation more desirable than an internal? What is the advantage by using inlet stratifiers? To answer the questions, theoretical investigations are carried out for differently designed solar combi systems. The work is carried out within the Solar Heating and Cooling Programme of the International Energy Agency (IEA SHC), Task 32 Advanced storage concepts for solar houses and low energy buildings.
Investigations of fabric stratifiers for solar tanks

The thermal performance of solar heating systems is strongly influenced by the thermal stratification in the heat storage. The higher the degree of thermal stratification is, the higher the thermal performance of the solar heating systems. Thermal stratification in water storages can be achieved in different ways. For instance, water heated by the solar collectors or water returning from the heating system can enter the water storage through stratification inlet devices in such a way that the water enters the tank in a level, where the tank temperature is the same as the temperature of the entering water. In this paper investigations of a number of different fabric stratification pipes are presented and compared to a non-flexible inlet stratifier. Additional, detailed investigations of the flow structure close to two fabric stratification pipes are presented for one set of operating conditions by means of the optical PIV (Particle Image Velocimetry) method.

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Andersen, E. (Intern), Furbo, S. (Intern), Fan, J. (Intern)
Publication date: 2005

Host publication information
Volume: CD-ROM
Publisher: International Solar Energy Society
ISBN (Print): 0-89553-177-1
Investigations of fabric stratifiers for solar tanks

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Andersen, E. (Intern)
Publication date: 2005

Investigations of medium sized solar heating systems

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Andersen, E. (Intern)
Publication date: 2005

Investigations of solar combi systems
A large variety of solar combi systems are on the marked to day. The best performing systems are highly advanced energy systems with thermal stratification manifolds, an efficient boiler and only one control system, which controls both the boiler and the solar collector loop (Weiss et al., 2003). However, it is still too early to draw conclusions on the design of solar combi systems. Among others, the following questions needs to be answered: Is an external domestic hot water preparation more desirable than an internal domestic hot water preparation? Is a stratification manifold always more desirable than a fixed inlet position? This paper presents experimental investigations of an advanced solar combi system with thermal stratification manifold inlets both in the solar collector loop and in the space heating system and with an external domestic hot water preparation. Theoretical investigations are carried out for different solar combi system types by means of the simulation program Trnsys (Klein et al., 1996) and the multiport store model (Drück, 2000) with input to the models determined by the experiments. The work is carried out within the Solar Heating and Cooling Programme of the International Energy Agency (IEA SHC), Task 32.

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Andersen, E. (Intern), Furbo, S. (Intern)
Publication date: 2005

Host publication information
Title of host publication: ISES 2005 Solar world congress : Proceedings of the 2005 Solar world congress
Volume: CD-ROM
Publisher: International Solar Energy Society
ISBN (Print): 0-89553-177-1
Main Research Area: Technical/natural sciences
Conference: ISES 2005 Solar World Congress, Orlando, FL, United States, 06/08/2005 - 06/08/2005
Source: orbit
Source-ID: 184511
Performance improvement by discharge from different levels in solar storage tanks

The thermal advantages by utilizing discharge from different levels in solar storage tanks are investigated, both for a small SDHW system and for a solar combisystem. The investigations showed that it is possible to increase the thermal performance of both types of systems by using two draw-off levels from the solar tanks instead of one draw-off level at a fixed position. The best position of the second draw-off level is in the middle or just above the middle of the tank. For the investigated small SDHW system with a realistic draw off hot water temperature of 40°C and 45°C and an auxiliary volume temperature of 50.5°C the increase of the thermal performance by the second draw-off level is about 6%. For the investigated solar combisystem the extra thermal performance by using one extra draw-off level, either for the domestic hot water heat exchanger or for the heating system, is about 3%, while an improvement of about 5% is possible by using a second draw-off level both for the domestic hot water heat exchanger and for the heating system.
Smart solar tanks for small solar domestic hot water systems

Investigation of small SDHW systems based on smart solar tanks are presented. The domestic water in a smart solar tank can be heated both by solar collectors and by means of an auxiliary energy supply system. The auxiliary energy supply system – in this study electric heating elements – heats up the hot-water tank from the top and the water volume heated by the auxiliary energy supply system is fitted to the hot-water consumption and consumption pattern. In periods with a large hot-water demand, the volume is large; in periods with a small hot-water demand, the volume is small. Two small SDHW systems, based on differently designed smart solar tanks and a traditional SDHW system were investigated by means of laboratory experiments and theoretical calculations. The investigations showed that the yearly thermal performance of
SDHW systems with smart solar tanks is 5-35% higher than the thermal performance of traditional SDHW systems. Estimates indicate that the performance/cost ratio can be improved by up to 25% by using a smart solar tank instead of a traditional tank when the backup energy system is electric heating elements. Further, smart solar tanks are suitable for unknown, variable, large or small hot-water consumption and the risk of oversized solar heating systems and oversized tank volumes is reduced by using smart solar tanks. Based on the investigations it is recommended to start development of smart tank units with an oil-fired boiler or a natural gas burner as auxiliary energy supply system.

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Furbo, S. (Intern), Andersen, E. (Intern), Knudsen, S. (Intern), Vejen, N. K. (Intern), Shah, L. J. (Intern)
Pages: 269-279
Publication date: 2005
Conference: ISES Solar World Congress 2003, Gothenburg, Sweden, 14/06/2003 - 14/06/2003
Main Research Area: Technical/natural sciences

Publication information
Journal: Solar Energy
Volume: 78
Issue number: 2
ISSN (Print): 0038-092X
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 4.89 SJR 1.615 SNIP 1.791
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 4.52 SJR 1.504 SNIP 1.746
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.912 SNIP 2.085 CiteScore 4.61
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.962 SNIP 2.671 CiteScore 4.77
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.99 SNIP 2.85 CiteScore 4.44
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.605 SNIP 2.517 CiteScore 3.65
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.283 SNIP 2.178 CiteScore 3.19
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.369 SNIP 2.16
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.265 SNIP 2.158
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.684 SNIP 1.994
Web of Science (2008): Indexed yes
SDHW systems, Smart solar tanks, Smart control strategy, Experiments, Calculations

DOIs:
10.1016/j.solener.2004.08.022

Source: orbit
Source-ID: 183154
Publication: Research - peer-review › Conference article – Annual report year: 2005

Theoretical and Experimental investigations of Inlet Stratifiers for Solar Storage Tanks.

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Shah, L. J. (Intern), Andersen, E. (Intern), Furbo, S. (Intern)
Pages: 2086-2099
Publication date: 2005
Main Research Area: Technical/natural sciences

Publication information
Journal: Applied Thermal Engineering
Volume: 25
Issue number: 14-15
ISSN (Print): 1359-4311
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 4.14 SJR 1.505 SNIP 1.837
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Advantages by discharge from different levels in solar storage tanks

General information
State: Published
Organisations: Department of Civil Engineering
Authors: Furbo, S. (Intern), Andersen, E. (Intern), Thür, A. (Intern), Shah, L. J. (Intern), Andersen, K. D. (Ekstern)
Publication date: 2004

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 183136
Publication: Research - peer-review › Journal article – Annual report year: 2005
Advantages by discharge from different levels in solar storage tanks

General information
State: Published
Organisations: Department of Civil Engineering
Authors: Furbo, S. (Intern), Andersen, E. (Intern), Thür, A. (Intern), Shah, L. J. (Intern), Andersen, K. D. (Ekstern)
Pages: 282-291
Publication date: 2004

Experimental and theoretical investigations of different water storages for solar combi systems

General information
State: Published
Organisations: Department of Civil Engineering, Section for Building Physics and Services
Authors: Andersen, E. (Intern)
Publication date: 2004
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 140799
Publication: Research › Paper – Annual report year: 2004

Investigation of the Solvis stratification inlet pipe for solar tanks

Since the 1960's the influence of the thermal stratification in hot water tanks on the thermal performance of solar heating systems has been studied intensively. It was found, that the thermal performance of a solar heating system is increasing for increasing thermal stratification in the hot water tank. The temperature of the storage water heated by the solar collector loop usually varies strongly during the day. In order to reach a good thermal stratification in the tank, different types of pipes, plates, diffusers and other devices have been investigated in the past (e.g. Loehrke, 1979). The aim pursued was to transport the heated water into the tank level of corresponding temperature. Flexible stratification pipes (manifolds) have been further developed for example by (Gari et al., 1982). Furthermore, a wide variety of non flexible tubes with either open holes and perforated vertical plates inside the pipes (Davidson, 1992) or openings in form of balls (e.g. Leibfried, 2000) or flaps (e.g. described in Krause, 2001) have entered the market during the recent years. In this paper an investigation of a stratification pipe with openings covered with flaps according to (Krause, 2001) is presented. The flaps are constructed with a soft material which allows the flap to close and open depending on the temperature and pressure differences inside and outside the pipe. Figure 1 shows schematic illustrations of the pipe. The total height of the pipe is 328 mm, the outer diameter 60 mm, and the flaps are located with a distance of 292 mm in vertical direction (distance between the centre of each opening). Fig. 1. Schematic illustrations of the investigated stratification inlet pipe. Preliminary laboratory tests by (Shah, 2002) with the same stratification pipe containing 5 openings showed that thermal stratification was well built up for a volume flow rate smaller than 8 l/min and larger than 4 l/min, regardless of the inlet temperature, the temperature level in the tank, and the thermal stratification in the tank. For volume flow rates larger than 8 l/min, however, the number of open flaps increased, so that water entered the tank at different levels instantaneously. For volume flow rates smaller than 4 l/min laboratory tests indicated that cold water could be sucked in through an opening in a low level due to low pressure differences. The cold water that entered the pipe through these openings from the bottom of the store mixed with the heated water that flew through the pipe and thereby induced mixing in the tank during charging. More detailed investigations of the flow structure close to the flaps of the stratification pipe are presented in the following for one set of operating conditions. Temperature measurements were carried out and an optical method called Particle Image Velocimetry (PIV) was used to visualize the flow around the flaps.

General information
State: Published
Organisations: Department of Civil Engineering
Authors: Andersen, E. (Intern), Jordan, U. (Intern), Shah, L. J. (Intern), Furbo, S. (Intern)
Investigations of the SOLVIS stratification inlet pipe for solar tanks

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Andersen, E. (Intern)
Publication date: 2004
Event: Poster session presented at EuroSun 2004, Freiburg, Germany.
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 195110
Publication: Research - peer-review › Poster – Annual report year: 2004

The influence of the solar radiation model on the calculated solar radiation from a horizontal surface to a tilted surface

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Andersen, E. (Intern)
Publication date: 2004
Event: Poster session presented at EuroSun 2004, Freiburg, Germany.
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 195112
Publication: Research - peer-review › Poster – Annual report year: 2004

Measured solar radiation data are most commonly available as total solar radiation on a horizontal surface. When using solar radiation measured on horizontal to calculate the solar radiation on tilted surfaces and thereby the thermal performance of different applications such as buildings and solar heating systems, different solar radiation models can be used. The calculation of beam radiation from a horizontal surface to a tilted surface can be done exactly whereas different solar radiation models can calculate the sky diffuse radiation. The sky diffuse radiation can either be assumed evenly distributed over the entire sky dome and calculated as pure isotropic radiation or by anisotropic radiation models that also uses contribution from circumsolar radiation in the calculation or by anisotropic radiation models that apart from the
isotropic and circumsolar contribution uses horizon brightening in the calculation. The weather data are measured at the solar radiation measurement station, SMS at the Department of Civil Engineering at the Technical University of Denmark. In this study the weather data are combined with solar collector calculations based on solar collector test carried out at Solar Energy Center, SEC, Denmark. With measured solar radiation on horizontal and the different solar radiation processing models the total radiation is calculated on differently tilted and oriented surfaces and compared with the measured solar radiation on the different surfaces. Further, the impact on the yearly thermal performances of a solar collector using the different solar radiation processing models is investigated. The study shows that the isotropic diffuse radiation model is underestimating the diffuse radiation from south and overestimating the diffuse radiation from north, while the anisotropic models give a better estimate on the diffuse radiation from all directions.

General information
State: Published
Organisations: Department of Civil Engineering
Authors: Andersen, E. (Intern), Lund, H. (Intern), Furbo, S. (Intern)
Pages: 747-756
Publication date: 2004

Host publication information
Title of host publication: Proceedings Eurosun
Volume: 3
Place of publication: Germany
Publisher: PSE GmbH
ISBN (Print): 3-9809656-3-5
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 61005
Publication: Research - peer-review › Article in proceedings – Annual report year: 2004

Thermal performance of Danish solar combi systems in practice and in theory
An overview of measured thermal performances of Danish solar combi systems in practice is given. The thermal performance varies greatly from system to system. Measured and calculated thermal performances of different solar combi systems are compared and the main reasons for the different thermal performances are given. Further, a parametric study on two solar combi system types is performed. Based on the investigation it can be concluded that the thermal performance first of all is influenced by the space heating consumption during the summer period and that the systems in practice perform as theoretically expected.

General information
State: Published
Organisations: Department of Civil Engineering
Authors: Andersen, E. (Intern), Shah, L. J. (Intern), Furbo, S. (Intern)
Pages: 744-749
Publication date: 2004
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of solar energy engineering
Volume: 126
Issue number: 2
ISSN (Print): 0199-6231
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): SNIP 0.891 SJR 0.615 CiteScore 1.61
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.37 SJR 0.57 SNIP 0.881
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.879 SNIP 1.272 CiteScore 1.65
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.801 SNIP 1.351 CiteScore 1.75
Ph.D. project on solar combi systems

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Andersen, E. (Intern)
Publication date: 2003
Smart solar tanks for small solar domestic hot water systems

The influence of weather on the thermal performance of solar heating systems

The influence of weather on the thermal performance of solar combi systems, solar domestic hot water systems and solar heating plants is investigated. The investigation is based on weather data from the Danish Design Reference Year, DRY and weather data measured for a period from 1990 until 2002. The investigation is based on calculations with validated models. Solar heating systems with different solar collector types, heat storage volumes and solar fractions are included in the investigation. The yearly solar radiation varies with approximately 20 % in the period from 1990 until 2002. The calculations show that the thermal performance of the investigated systems varies due to the weather variation. The variation of the yearly thermal performance of a solar heating plant is about 40 % while the variation of the yearly thermal performance of a solar domestic hot water system is about 30 % and the variation of the yearly thermal performance of a combi system is about 25 %.
The influence weather on the thermal performance of solar heating systems

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Andersen, E. (Intern)
Publication date: 2003

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 195108
Publication: Research › Sound/Visual production (digital) – Annual report year: 2003

Vejrets indflydelse på solvarmeanlægs ydelse

General information
State: Published
Organisations: Department of Civil Engineering
Authors: Andersen, E. (Intern)
Publication date: 2003
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 61052
Publication: Research › Paper – Annual report year: 2003

Afprøvning af solvarmeanlæg med Gas-Sol Compact

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Vejen, N. K. (Intern), Andersen, E. (Intern)
Publication date: 2002

Publication information
Original language: Danish
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 63955
Publication: Research › peer-review › Report – Annual report year: 2002

Afprøvning af solvarmeanlæg med Nilan Sunshine Ecotec naturgaskedel-soltank-unit til brugsvand og rumopvarmning

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Andersen, E. (Intern)
Publication date: 2001

Publication information
Original language: Danish
Series: BYG Sagsrapport
Number: SR 01-12
Main Research Area: Technical/natural sciences
Electronic versions: byg-sr0112.pdf
Source: orbit
Source-ID: 190315
Publication: Research › Report – Annual report year: 2001
Design of combi systems
Investigations have shown that the thermal performance of Danish combi systems is a subject of large variations from system to system. Some systems are well performing, however, more systems have a poor performance. [Ellehauge K et al (2000)]. Most of the combined systems that are installed in Denmark correspond to the system illustrated in Figure 1. The control system operates the three-way valve in the solar collector circuit so solar heat is supplied either to the storage tank or to the heat exchanger between the collector loop and the space-heating loop. [Ellehauge K, ShahL.J. (2000)] This paper addresses an experimentally and theoretically investigation of three different marketed combi systems. Two different combi systems, based on the above mentioned system design, with units where the auxiliary energy supply system is built into the same cabinet as the hot-water tank and one combi system based on a tank in tank heat storage are investigated experimentally in a laboratory test facility. One of the units is based on a mantle tank the other is based on a tank with a built-in heat exchanger spiral. The thermal performances of the systems in the laboratory test facility are measured with constant daily hot water consumption, consumption patterns and space heating demand for all days, and the results are used to validate TrnSys models. Based on simulation models of the combi systems, the thermal behavior is simulated and the thermal performance and the solar fraction of the systems is determined. The calculations are based on the simulation program Trnsys [Klein S.A et al. (1996)] and weather data from the Danish Design Reference Year, DRY. The paper will present and compare measured and calculated thermal performances and solar fractions of different combi systems and the main reasons for the different thermal performances and solar fractions for the investigated systems will be given. Further, the paper will present the results of an optimisation of the combi systems in question. The optimisation of the systems is based on experience from the measurements and calculations with the validated simulation models where a number of different design-, control- and consumption parameters are varied.

### General information
State: Published
Organisations: Department of Civil Engineering
Authors: Andersen, E. (Intern), Shah, L. J. (Intern), Furbo, S. (Intern)
Pages: 659-668
Publication date: 2001

### Host publication information
Title of host publication: International solar energy society 2001 solar world congress: Bringing solar down to earth
Volume: 2
Place of publication: Australia and New Zealand
Publisher: Australian and New Zealand Solar Energy Society
ISBN (Print): 0-9586192-7-1
Main Research Area: Technical/natural sciences
Conference: International solar energy society 2001 solar world congress: Bringing solar down to earth, Australia, Adelaide, 01/01/2001
Source: orbit
Source-ID: 61007
Publication: Research - peer-review › Article in proceedings – Annual report year: 2001

Intelligente solvarmeanlæg: Udvikling og afprøvning

### General information
State: Published
Organisations: Department of Civil Engineering
Authors: Andersen, E. (Intern), Knudsen, S. (Intern), Furbo, S. (Intern), Vejen, N. K. (Intern)
Publication date: 2001

### Publication information
ISBN (Print): 87-7877-060-2
Original language: Danish

Series: BYG Rapport
Number: R-005
Main Research Area: Technical/natural sciences
Electronic versions:
byg-r005.pdf
Links:
http://www.byg.dtu.dk/publications/rapporter/byg-r005.pdf
Source: orbit
Source-ID: 61787
Publication: Research - peer-review › Report – Annual report year: 2001
Intelligente solvarmeanlæg med oliefyr eller gaskedel som backupenergi

General information
State: Published
Organisations: Department of Civil Engineering
Authors: Andersen, E. (Intern)
Publication date: 2001

Publication information
Original language: Danish
Series: BYG Sagsrapport
Number: SR 01-09
Main Research Area: Technical/natural sciences
Electronic versions:
byg-SR-0109.pdf
Source: orbit
Source-ID: 190313
Publication: Research › Report – Annual report year: 2001

Undersøgelse af gas-sol compact i lagerprøvestand

General information
State: Published
Organisations: Department of Civil Engineering
Authors: Andersen, E. (Intern), Trads, N. (Ekstern), Meier, A. (Ekstern)
Publication date: 2001

Publication information
Publisher: DTU Byg, Danmarks Tekniske Universitet
Original language: Danish
Series: BYG Sagsrapport
Number: SR 01-04
Main Research Area: Technical/natural sciences
Electronic versions:
byg-sr0104.pdf
Source: orbit
Source-ID: 190311
Publication: Research › Report – Annual report year: 2001

Smart SDHW systems.

General information
State: Published
Organisations: Department of Buildings and Energy
Authors: Andersen, E. (Intern)
Publication date: 2000

Publication information
Original language: Danish
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 174918
Publication: Research - peer-review › Report – Annual report year: 2000

Cold water inlet in solar tanks - valuation.

General information
State: Published
Organisations: Department of Buildings and Energy
Authors: Andersen, E. (Intern)
DEVELOPMENT OF A SMART SOLAR TANK

General information
State: Published
Organisations: Department of Buildings and Energy, Technical University of Denmark
Authors: Furbo, S. (Ekstern), Andersen, E. (Intern)
Publication date: 1999

Host publication information
Title of host publication: DEVELOPMENT OF A SMART SOLAR TANK
Main Research Area: Technical/natural sciences
Conference: ISES 1999 Solar World Congress, Jerusalem, Israel, 04/07/1999 - 04/07/1999
Source: orbit
Source-ID: 173629
Publication: Research - peer-review › Article in proceedings – Annual report year: 1999

Development of smart solar tanks.

General information
State: Published
Organisations: Department of Buildings and Energy
Authors: Furbo, S. (Intern), Andersen, E. (Intern)
Publication date: 1999

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 174703
Publication: Research - peer-review › Report – Annual report year: 1999

Thermal destratification in small standard solar tanks due to mixing during tapping

Most small solar domestic hot water systems, SDHW systems, are not equipped with circulation piping. In many systems, the pipes, in which the hot water is transported from the solar tank to the draw-off locations, are relatively long. Hence, the waiting time for hot water during draw-off is relatively long. In order to reduce this waiting time to an acceptable level, the flow rate during draw-off is often very large – typically about 20 l/min. – at least at the start of the draw-off. As long as the flow rate during draw-off is small, the mixing rate inside the tank is small. However, if the flow rate is large, as mentioned above, the mixing rate can be relatively large if the cold-water inlet design is poor. Mixing results in destratification in the solar tank and with that reduced thermal performance of the SDHW system. Investigations indicate that the decrease of the yearly thermal performance caused by mixing during draw-offs can be as high as 23% if a marketed cold-water inlet design is used. Other tested inlet designs result in a decrease of 2-3% of the yearly thermal performance caused by mixing. Based on the investigations recommendations on the design of the cold-water inlet and on a test method for solar tanks concerning mixing during draw-offs are given.

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Andersen, E. (Intern), Furbo, S. (Intern)
Publication date: 1999

Host publication information
Title of host publication: Proceedings of ISES 1999 Solar World Congress
Main Research Area: Technical/natural sciences
Conference: ISES 1999 Solar World Congress, Jerusalem, Israel, 04/07/1999 - 04/07/1999
Thermal destratification in small standard solar tanks due to mixing during tapping.

General information
State: Published
Organisations: Department of Buildings and Energy
Authors: Andersen, E. (Intern), Furbo, S. (Intern)
Publication date: 1999

Host publication information
Title of host publication: Thermal destratification in small standard solar tanks due to mixing during tapping
Main Research Area: Technical/natural sciences
Conference: ISES 1999 Solar World Congress, Jerusalem, Israel, 04/07/1999 - 04/07/1999
Source: orbit
Source-ID: 173632
Publication: Research - peer-review › Book chapter – Annual report year: 1999

Mixing during draw-off in small SDHW systems.: Proposal for maximum acceptable mixing.

General information
State: Published
Organisations: Department of Buildings and Energy
Authors: Andersen, E. (Intern), Furbo, S. (Intern)
Number of pages: 12
Publication date: 1998

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 170681
Publication: Research - peer-review › Report – Annual report year: 1998

Simple characterisation of solar DHW tanks.

General information
State: Published
Organisations: Department of Buildings and Energy
Authors: Andersen, E. (Intern), Furbo, S. (Intern)
Number of pages: 29
Publication date: 1998

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Temperature stratification in a hot water tank with circulation pipe.

**General information**
- State: Published
- Organisations: Department of Buildings and Energy
- Authors: Andersen, E. (Intern)
- Number of pages: 38
- Publication date: 1998

**Publication information**
- Original language: Danish
- Main Research Area: Technical/natural sciences
- Source: orbit
- Source-ID: 174693
- Publication: Research - peer-review › Report – Annual report year: 1998

Thermal performance of small solar domestic hot water systems in theory, in the laboratory and in practice.

**General information**
- State: Published
- Organisations: Department of Buildings and Energy
- Authors: Andersen, E. (Intern)
- Publication date: 1998

**Host publication information**
- Title of host publication: Thermal performance of small solar domestic hot water systems in theory, in the laboratory and in practice.
- Main Research Area: Technical/natural sciences
- Source: orbit
- Source-ID: 171031
- Publication: Research - peer-review › Book chapter – Annual report year: 1998

Testing of Solar Heated Domestic Hot Water System for Solahart Scandinavia ApS

**General information**
- State: Published
- Organisations: Department of Buildings and Energy
- Authors: Andersen, E. (Intern)
- Publication date: 1997

**Publication information**
- Original language: Danish
- Main Research Area: Technical/natural sciences
- Source: orbit
- Source-ID: 168908
- Publication: Research - peer-review › Report – Annual report year: 1997

Test of a small SDHW-system form the company Solahart Scandinavia ApS.

**General information**
- State: Published
- Organisations: Department of Buildings and Energy
- Authors: Andersen, E. (Intern)
- Number of pages: 30
- Publication date: 1997

**Publication information**
- Original language: Danish
Projects:

IEA SHC Task 55 - Integration of Large SHC Systems into District Heating and Cooling (DHC) Networks (II)
The aim of the project is - through exchange of international knowledge - to develop and promote solar district heating plants. Denmark is in front in this field and the project gives good opportunities for promotion of Danish know how and technology. The overall objective is to increase the use of solar thermal energy throughout the world.

Project description

The project activities and expected outcomes are:
System description and design of low cost and high performance large-sized SDH and SDC systems as well as the design and evaluation of large scale seasonal storages and hybrid technologies. Further, technical analyses of findings will be presented within a report for city district planners, dealing with the integration of solar thermal and seasonal storages. Additionally, a specific report for planners will focus on system requirements for SDH and SDC, modular conception and construction as well as the minimization of piping and losses. Established business and financing models: Objectives here are reference calculation models of SDH and SDC as well as economical requirement definitions for new systems and markets. Guidelines to secure low operation and maintenance efforts for very large systems including automated operational surveillance. Advanced control systems for large-sized solar and hybrid systems. A comparison of measured collector performances in the field, and singular collector tests in the laboratory. Results will be the basis for a validated measurement method of solar collector fields and the validation of performance guarantee procedures. Data for the optimization of very large collector fields’ performances based on adjusted hydraulics and minimized system losses. Promotion and technology spread of large systems in new markets through the continuation of the existing database from the IEA SHC Task 45, 48 and 49. Country reports including case studies and feasibilities.

Department of Civil Engineering

Energy and Services
Period: 01/01/2019 → 31/12/2020
Number of participants: 7
Large solar heating plants, District heating and cooling, System integration, Solar collector field, Large heat storages, Performance analysis, Business models, System controls
Acronym: IEA Task 55
Project participant:
Fan, Jianhua (Intern)
Furbo, Simon (Intern)
Perers, Bengt (Intern)
Kong, Weiqiang (Intern)
Dragsted, Janne (Intern)
Nielsen, Elsabet Nomonde Noma (Intern)
Jensen, Adam Rasmus (Intern)

Financing sources
Source: Public research council
Name of research programme: EUDP

IEA PVPS Task 16 Solar resource for high penetration
The purpose of this project is to develop better recommendations for understanding the solar energy resource in energy systems with high degree of renewable energy penetration. This is done as an international collaboration within the IEA PVPS programme.

Project description

With increasingly high penetration of PV, concentrating solar power (CSP), and solar heating plants into our energy and
heating systems around the world, increased knowledge on the solar radiation potential become ever more important.

During meetings in 2015 and 2016 a detailed work plan was made for an upcoming task in the framework of the International Energy Agency Photovoltaic Power Systems Programme (IEA PVPS) to address the issues outlined above. The task entitled: “Solar resource for high penetration and large scale applications” was approved by the IEA PVPS Executive Committee in November 2016 as IEA PVPS Task 16. The task runs for three years from 2017 to 2020.

DTU will continue the work done in the IEA SHC Task 46 (2011-2016), where the focus was on the directional and temporal variability of the solar resource. Now the focus will be on how this affects the energy production in the rows of large scale solar collector and PV fields.

Department of Civil Engineering

Energy and Services
Period: 01/01/2018 → 31/12/2020
Number of participants: 6
Solar resource, high penetration renewable energy systems, Solar heating plants, PV, CSP Concentrating solar power
Acronym: IEA Task 16
Project participant:
Fan, Jianhua (Intern)
Furbo, Simon (Intern)
Dragsted, Janne (Intern)
Nielsen, Elsabet Nomonde Noma (Intern)
Perers, Bengt (Intern)
Kong, Weiqiang (Intern)

Financing sources
Source: Public research council
Name of research programme: EUDP

Highly Efficient and Simplified Thermodynamic Cycle with Isolated Heating and Cooling – Cost Optimized
The project will develop a new combined heating/cooling system that efficiently and continuously produces hot and/or cold water with up to 30 % larger efficiency that conventional heat pump and cooling systems and generates a possibility of accumulating heat and/or cooling.

Depending on the operating conditions, an efficiency improvement of 10-50 % is shown in a completed EUDP project by employing the tank system for heating. An additional increase of 15 % is expected to be achieved by simultaneous use of the tank system for cooling also. A further advantage of the concept is the possibility of accumulation hot and cold water.

A major performance improvement can be achieved. However, it is also shown that costs of the technology provide some challenges. By studying the framework of the technology, both the temperature operating range and the economy when using this system could be increased significantly.

Thus, the focus of the ISECOP project is the development of components and the control system to achieve optimal interaction between the heat pump, the heat storage and the heat consumption. Indeed, it will be possible to construct certain essential components, e.g. the compressor, in a simpler way (e.g. without capacity control) by using the ISECOP concept.

Department of Civil Engineering
Energy and Services
Danish Technological Institute
Department of Mechanic Engineering, Technical University of Denmark
Vengcon
Alfa Laval Corporate AB
METRO THERM A/S
Svedan Industri Køleanlæg
CHR Møller
Egå smedegård og maskinfabrik

ARLA FOODS AMBA
Period: 01/01/2018 → 31/12/2020
Number of participants: 4
Heating and cooling, Heat pumps, Heat storages, CFD calculations, Trnsys simulations
Acronym: ISECOP
Project participant:
Fan, Jianhua (Intern)
Furbo, Simon (Intern)
Nielsen, Elsabet Nomonde Noma (Intern)
Kong, Weiqiang (Intern)

Financing sources
Source: Public research council
Name of research programme: EUDP
Web address: https://ens.dk/
Amount: 5,950,000.00 Danish Kroner
Year of approval: 2017

European Committee for Standardization (CEN) Project ECOTEST
This project is funded by European Committee for Standardization (CEN) under the following EU regulations:
Supplementing Directive 2010/30/EU of the European Parliament and of the Council with regards to the energy labelling of space heaters etc.
Supplementing Directive 2010/30/EU of the European Parliament of the Council with regard to the energy labelling of water heaters etc.
The project is focused on evaluation of the standards used and measurement reproducibility of EU laboratories for the application of Ecodesign requirements and labelling of heating and hot water production appliances.
There are eight work packages:
• WP 1 Emissions - CEN/TC 238 (including sound power level)
• WP2 Uncertainty calculation method of the emissions, efficiency and all other parameters and common protocols for the INTER-COMPARISON + uncertainties
• WP3 Ecodesign testing of sanitary hot water work package with CEN/TC 109
• WP4 Work package with CEN/CENELEC JWG FCGA (on mCHP)
• WP5 Work package with CEN/TC 299 (on gas heat pump)
• WP6 Work package with CEN/TC 57 (fuel oil boilers)
• WP7 Work package with CEN/TC 113 (electrical heat pumps)
• WP8 Work package with CEN/TC 312 (solar heaters)
Overall objectives:
1: EVALUATION OF EU LABORATORIES: “to provide for each parameter measured for the application of (EU) No 811/12/13/14 2013 and each appliance a value of the inter-laboratory reproducibility obtained with the test procedures of the corresponding standard developed”
2: EVALUATION OF EU STANDARDS: “to propose improvements of the procedures from the standards”
3: EVALUATION OF EU market surveillance TOLERANCES: “to propose for all parameters and appliances tested a value of a reasonable tolerance that shall be used for the market surveillance”.

Department of Civil Engineering
Energy and Services
Danish Gas Technology Centre A/S
Instytut Nafty i Gazu –Państwowy Instytut Badawczy
KIWA Gastec Netherland
DVGW-Forschungsstelle EBI
Centre Technique des Industries Aérauliques et Thermiques
IGE-HLK
APPLUS Laboratories
IEA Task 46 Solar resource assessment and forecasting
Solar radiation in a solar collector field in Høje Tåstrup is measured and analysed. Thermal performances of solar collector fields are calculated with solar radiation measured in the period 2001-2010 for different locations in Denmark. Detailed solar radiation models for the diffuse radiation are developed.

Department of Civil Engineering
Section for Building Energy

Danish Meteorological Institute
Period: 01/01/2016 → 31/12/2016
Number of participants: 2
Solar radiation, diffuse radiation
Acronym: IEA Task 46
Project participant:
Furbo, Simon (Intern)
Nielsen, Elsabet Nomonde Noma (Intern)

Follow up on large scale storage in Denmark, Gram
In the project the performance of the pit heat storage in Gram will be followed. The monitoring results and experience for operation of storage until 2018 will be analyzed and published.
Project description
In 2014-2015 two new large heat storage have been implemented in Denmark in Vojns and Gram. The two storages have similar design. Before that, 3 large storages were implemented in Braedstrup, Marstal and Dronninglund from 2011-2013. Monitoring results from these 3 storages are analyzes in the project "Opfølgningsprogram for store varmelagre i Danmark" (EUDP 14-I, j.nr. 64014-0121) lasting indtill 30.06.2018.
Since the design of the pit heat storages Vojns and Gram differs from the design of the pit heat storage in Marstal and Dronninglund it is important to establish similar monitoring and analysis at least one of those storages. The performance of the pit heat storage in Gram will therefore in this project be monitored in a similar way as the performance of the storage in “Opfølgningsprogram for store varmelagre i Danmark”. Especially for Gram will monitoring of the performance of new and cheaper pit construction.

SDH (Solar District Heating) Conference will be arranged in Denmark in 2016. This will be an excellent possibility promote Danish solar solutions. Therefore support to SDH conference is included in the dissemination part of this project. 150 stakeholders from more than 20 countries are expected to participate. The intention is to arrange the conference in Billund and use Gram as the main stop at the technical tour.

Department of Civil Engineering

Energy and Services

PlanEnergi

Solites

Rambøll Danmark A/S

Kristensen Consulting

Period: 01/01/2016 → 31/12/2018

Number of participants: 5

Large scale heat storages, Long term measurement, Performance analysis

Project participant:

Fan, Jianhua (Intern)

Furbo, Simon (Intern)

Perers, Bengt (Intern)

Kong, Weiqiang (Intern)

Nielsen, Elsabet Nomonde Noma (Intern)

Financing sources

Source: Public research council

Name of research programme: EUDP

Project

Air collector for dehumidification

The aim is to develop an advanced air collector which can be used for dehumidification of buildings. The collector is equipped with a layer of silica gel. The silica gel can contain more or less water. During sunny days solar radiation is used to dry out the silica gel. During nights outdoor air is, by passing through the collector, dehumidified by the silica gel. An air collector is tested in a laboratory test facility.

Department of Civil Engineering

Section for Building Energy

Solar Venti A/S

Cenergia

Aros teknik ApS

Period: 01/09/2015 → 31/03/2017

Number of participants: 2

Project participant:

Furbo, Simon (Intern)

Nielsen, Elsabet Nomonde Noma (Intern)

Project

Experimental and theoretical investigations of combined solar heating/heat pump systems for single Family houses

Renewable energy systems based on the combination of solar heating systems and electrical driven auxiliary energy supply systems such as heat pumps are becoming very attractive solutions as the heating and cooling systems in single family houses. The combined solar heating/heat pump systems provide all the needed yearly heating and cooling demand in single family houses. The most widely used energy sources for the heat pumps are the ambient air, ground source heat exchangers or borehole heat exchangers. Heat pumps that use ambient air as heat source need fans and these can create disturbing noise. Further, heat pumps that use ambient air as heat source run with low efficiency in cold winter periods. The heat source temperature is more stable with ground source heat exchanger or borehole heat exchanger. In systems with ground source heat exchangers or borehole heat exchangers, excess energy production from the solar
collectors is also sometimes lead into the ground for recharging the ground heat source. Produced energy that cannot be directly used is usually lead into the ground in order to protect the system from overheating.

The aim of this project is to increase the knowledge of the heat and mass transfer in combined solar heating/heat pump systems that uses of a ground source heat exchanger. Such a system is installed and tested at DTU Byg.

Department of Civil Engineering
Section for Building Physics and Services
Period: 01/07/2013 → 30/06/2016
Number of participants: 5
Project ID: 26309
Project participant:
Nielsen, Elsabet Nomonde Noma (Intern)
Perers, Bengt (Intern)
Furbo, Simon (Intern)
Dandanell, Jens Martin (Intern)
Aagaard, Claus (Intern)

EUDP 12-II, IEA Task 42 Compact Thermal Energy Storage 2. period
The project is the Danish contribution to the IEA SHC Programme Task 42 project "Compact Energy storage: Material Development and System Integration, 2nd period".

A seasonal heat storage based on sodium acetate trihydrate with stable supercooling marketed by the German company H.M. Heizkörper GmbH & Co. KG will be evaluated in terms of thermal performance and economy by means of detailed experimental and theoretical investigations.

A seasonal heat storage based on a salt water mixture consisting of sodium acetate and water is currently being developed by Technical University of Denmark, Graz University of Technology, Nilan A/S and Velux A/S in the COMTES project supported by EU. This storage will be compared to the German heat storage.

Calculations of the thermal performance of solar heating systems with the two above mentioned heat stores will be carried out with validated simulation models. The calculations will show how the designs of the solar heating systems including the seasonal heat stores will influence the size of the systems needed to fully cover the yearly heat demand of new buildings.

Based on the calculations and on evaluation of the economic conditions the optimum design and the suitability of the two heat stores will be elucidated.

Department of Civil Engineering
Section for Building Physics and Services
Period: 02/01/2013 → 31/12/2015
Number of participants: 5
Compact sesonal heat storage, PCM, Sodium acetate, Supercooling
Acronym: Task 42
Number of related Ph.D. students: 1
Project participant:
Furbo, Simon (Intern)
Dannemand, Mark (Intern)
Fan, Jianhua (Intern)
Dragsted, Janne (Intern)
Nielsen, Elsabet Nomonde Noma (Intern)

Financing sources
Source: Forskningsprojekter - Miljø- og Energimisteriet
Name of research programme: EUDP
Amount: 2,799,000.00 Danish Kroner
Year of approval: 2012

Relations
Activities:
IEA Task 42 / Annex 29, 12th expert meeting
Advanced Solar Resource Assessment and Forecasting
Detailed measurements and solar radiation models on diffuse radiation from different parts of the sky.

Department of Civil Engineering
Section for Building Physics and Services
Danish Meteorological Institute
Period: 01/09/2012 → 30/09/2015
Number of participants: 3
Acronym: IEA Task 46
Project participant:
Furbo, Simon (Intern)
Dragsted, Janne (Intern)
Nielsen, Elsabet Nomonde Noma (Intern)

IEA Task 44 Systems Using Solar Thermal Energy in Combination with Heat Pumps
The Task aims at optimizing combinations of solar thermal energy and heat pump, primarily for one family houses.

Department of Civil Engineering
Section for Building Physics and Services
Danish Technological Institute
Cenergia
Nilan A/S
Ekolab
Period: 13/08/2012 → 31/05/2013
Number of participants: 3
Solar heating, Heat pumps, Combined systems
Acronym: Task 44
Project participant:
Furbo, Simon (Intern)
Perers, Bengt (Intern)
Nielsen, Elsabet Nomonde Noma (Intern)

Financing sources
Source: Forskningsprojekter - Miljø- og Energiministeriet
Name of research programme: EUDP programme
Amount: 257,760.00 Danish Kroner
Year of approval: 2012

Upgrade and extension of the Climate station at DTU Byg
In the period 2013-2014 the project "Upgrade and Extension of the Climate Station at DTU Byg" is carried out at DTU Byg. The aim of the project is to renew the hardware and the software for data acquisition and monitoring, exchange cables and cable connections in order to avoid interference of electrical noise from the surroundings and exchange worn out equipment. Further, the aim is to make measured data from the climate station easily available for the users.

Department of Civil Engineering
Section for Building Physics and Services
Period: 01/08/2012 → 31/10/2014
Number of participants: 4
Project ID: 26270
Project participant:
Nielsen, Elsabet Nomonde Noma (Intern)
Dragsted, Janne (Intern)
Andersen, Lars Kokholm (Intern)
Kristensen, Troels V. (Intern)
Financing sources
Source: Private funding (private)
Name of research programme: Bjarne Saxhofs Fond
Amount: 565,200.00 Danish Kroner
Year of approval: 2012

Relations
Publications:
Upgrade and extension of the climate station at DTU Byg
Fabric inlet stratification device
Product development of fabric inlet stratification device for hot water stores with focus on creating thermal stratification in the heat store during operation. Both technological and commercial objectives are considered.

Department of Civil Engineering
Section for Building Physics and Services
Period: 02/07/2012 → 31/01/2013
Number of participants: 4
Fabric inlet stratifier, Hot water storage, Thermal stratification
Project participant:
Furbo, Simon (Intern)
Dannemand, Mark (Intern)
Spanggaard, Martin (Ekstern)
Nielsen, Elsabet Nomonde Noma (Intern)

Combined development of compact thermal energy storage technologies
The aim of the project is to develop a seasonal heat storage consisting of heat storage modules with a salt water mixture of sodium acetate and water. The heat storage concept is based on the advantage of stable supercooling. By using this concept the heat storage module will have no heat loss for a long period making seasonal heat storage possible. If a sodium acetate water mixture, which has a melting point of 58°C, has been fully melted during the sunny summer, it can cool down in its liquid phase to the surrounding temperature and still preserve the latent heat related to the heat of fusion. The heat storage module can be left in this state with no heat loss until a heat demand occurs in the house in the winter, in which case solidification is activated, the heat of fusion is released, and the heat storage temperature increases almost immediately to the melting point.
The developed heat storage will be a part of a demonstration solar heating system which is intended to cover the total yearly heat demand and hot water consumption of a low energy one family house.

Department of Civil Engineering
Section for Building Physics and Services
Technische Universität Graz
Nilan A/S
Velux A/S
Period: 01/04/2012 → 31/03/2016
Number of participants: 8
Development, Demonstration, Seasonal heat storage, PCM, Supercooling
Acronym: COMTES
Project participant:
Furbo, Simon (Intern)
Fan, Jianhua (Intern)
Dragsted, Janne (Intern)
Chen, Ziqian (Intern)
Dannemand, Mark (Intern)
Nielsen, Elsabet Nomonde Noma (Intern)
Perers, Bengt (Intern)
Berg, Jakob Brinke (Intern)

Financing sources
Intelligent styresystem til fremtidens solvarmeanlæg

Section for Building Physics and Services

Department of Civil Engineering
Period: 14/12/2011 → 31/12/2012
Number of participants: 2
Project participant:
Nielsen, Elsabet Nomonde Noma (Intern)
Project Manager, organisational:
Furbo, Simon (Intern)

Optimal designs for hot water tanks for solar domestic hot water systems

The simulation program MANTLSIM was modified in such a way that the yearly thermal performance of small solar domestic hot water systems based on mantle tanks was calculated for typical weather conditions for Klagenfurt, Austria. Calculations of yearly thermal performances for this location were carried out for a solar domestic hot water system with differently designed mantle tanks. A report with the results of the calculations was worked out.

Section for Building Physics and Services

GREENoneTEC Solarindustrie GmbH
Period: 01/08/2011 → 31/12/2011
Number of participants: 4
Project participant:
Nielsen, Elsabet Nomonde Noma (Intern)
Dragsted, Janne (Intern)
Chen, Ziqian (Intern)
Project Manager, organisational:
Furbo, Simon (Intern)

Effektiviteten af en ny luftsolfanger

Section for Building Physics and Services

Venetian Solar ApS
Period: 01/07/2011 → 31/12/2011
Number of participants: 2
Project participant:
Nielsen, Elsabet Nomonde Noma (Intern)
Project Manager, organisational:
Furbo, Simon (Intern)
Sustainable energy
The aim of the project is to carry out research and education activities on Sustainable Energy within the SDC Center. The SDC Center is a joint project on education and research between the eight Danish universities, the Danish Ministry of Science, Technology and Innovation, the University of the Chinese Academy of Sciences (UCAS) and the Chinese Academy of Sciences (CAS). The overall aim of SDC is to promote and strengthen collaboration between Danish and Chinese research and learning environments for the benefit of both countries.

Department of Civil Engineering
Section for Building Physics and Services
Period: 01/07/2011 → 31/12/2013
Number of participants: 5
Sustainable Energy, Sino-Danish Research and Education Center, Solar Energy
Project ID: 26192
Project participant:
Fan, Jianhua (Intern)
Furbo, Simon (Intern)
Nielsen, Elsabet Nomonde Noma (Intern)
Perers, Bengt (Intern)
Chen, Ziqian (Intern)

Beregning af effektivitet af luftsolfangere
Department of Civil Engineering
Period: 01/10/2010 → 31/01/2011
Number of participants: 2
Project participant:
Nielsen, Elsabet Nomonde Noma (Intern)

Financing sources
Source: Sam.arb.aftaler, Private danske - Andre virksomheder
Name of research programme: Sam.arb.aftaler, Private danske - Andre virksomheder
Amount: 12,000.00 Danish Kroner

Test facility for air collectors
1. Objective of the project Renewable energy systems based on air solar collectors are used for dehumidification of buildings and heating of ventilation air for buildings. The aim of the project is to increase the knowledge of the heat and mass transfer in air solar collectors. This knowledge is the basis for improved marketed air solar collectors. 2. Background Air solar collectors are in Denmark installed in large numbers in summer houses with the aim to improve the indoor climate by dehumidification. The air solar collectors have integrated PV modules which provide electricity for integrated ventilation fans. In this way outdoor air is in sunny cold periods heated in the solar collector and by means of the fan blown into the houses. This kind of systems can also be used for heating of ventilation air. The system can also be extended with an additional ventilation fan which is placed on the north and shaded side of the building. When the temperature inside the building gets too high, a control system turns off the ventilation fan on the south and sunny side and turns on the ventilation fan on the north side. In this way cold air from the shaded part of the building can be used to cool down the building. Marketed air solar collectors are today designed based on manufacturer’s practical experience with special focus on the manufacturing process, the installation process and the operation of the system. Detailed knowledge of the thermal behaviour inclusive details on the heat and mass transfer in the air solar collector during operation is only to a small extent the basis for the design of the air solar collectors. Several companies in Denmark manufacture this kind of solar collectors, for instance Solar Venti A/S, Ans Solvarme and Dansolar and consumers must rely on product information given by manufacturers. There is a lack of detailed knowledge in this field, and there are no impartial institutes with test facilities for air collectors in Denmark. Further, there are no international standard test methods available for air solar collectors. 3. Project activities This project will establish the first part of the basis for development of air solar collector systems for dehumidification of buildings and heating of ventilation air for buildings. The first part contains the following activities: Establishing of a test facility for side-by-side tests of air solar collectors, Testing the efficiency of a marketed air solar collector.
collector and Contribute to development of test methods for air solar collectors within the international energy agency framework program, Task 43

Department of Civil Engineering
Period: 29/07/2010 → 31/12/2011
Number of participants: 3
Project ID: 26119
Contact person:
Nielsen, Elsabet Nomonde Noma (Intern)
Perers, Bengt (Intern)
Furbo, Simon (Intern)

Financing sources
Source: Udenfor rammen
Name of research programme: Ukendt
Amount: 4,990,769.00 Danish Kroner

Udvikling af profileret tagintegreret solfanger

Department of Civil Engineering
Nordic Energy Group ApS
Period: 08/06/2010 → 31/12/2012
Number of participants: 3
Project participant:
Chen, Ziqian (Intern)
Nielsen, Elsabet Nomonde Noma (Intern)

Project Manager, organisational:
Furbo, Simon (Intern)

Financing sources
Source: Sam.arb.aftaler, Private danske - Andre virksomheder
Name of research programme: Sam.arb.aftaler, Private danske - Andre virksomheder
Amount: 418,997.00 Danish Kroner

Optimization of solar heating and water heating combsystems applied in buildings

The project will be carried out by Beijing Solar Energy Research Institute Co. Ltd, China and Department of Civil Engineering, Technical University of Denmark. The Chinese partner will focus investigations on flat plate solar collectors and the Danish partner will focus on evacuated tubular solar collectors. The thermal performance of the different collectors will be compared both for Danish and Chinese climate. The Chinese partner will focus on traditional designed heat stores without a high degree of thermal stratification. The Danish partner will focus on highly stratified heat stores with built in inlet stratification devices. It will be elucidated how much the thermal performance will be improved for solar combi systems with advanced stratified heat storages instead of normal heat storages with limited thermal stratification both with Danish and Chinese weather data. Laboratory tests of solar combi systems, development of TRNSYS simulation models for solar combi systems and validation of the simulation models will be carried out. Solar combi systems will be developed based on TRNSYS calculations both for Danish and Chinese weather data and one family houses. The long term thermal performance of solar combi systems installed in demonstration houses in China and in Denmark will be measured.

Section for Building Physics and Services

Department of Civil Engineering
Period: 01/03/2010 → 31/12/2013
Number of participants: 5
Project participant:
Chen, Ziqian (Intern)
Fan, Jianhua (Intern)
Nielsen, Elsabet Nomonde Noma (Intern)
Perers, Bengt (Intern)

Project Manager, organisational:
Furbo, Simon (Intern)

Financing sources
Dansk deltagelse i IEA Task 44: Systems using solar thermal energy in combination with heat pumps

Section for Building Physics and Services
Department of Civil Engineering
Danish Technological Institute
Ellehauge og Kildemoes ApS
Nilan A/S

Period: 12/02/2010 → 31/03/2011
Number of participants: 3
Project participant:
Perers, Bengt (Intern)
Furbo, Simon (Intern)

Project Manager, organisational:
Nielsen, Elsabet Nomonde Noma (Intern)

Financing sources
Source: Forskningsprojekter - Miljø- og Energiministeriet
Name of research programme: Forskningsprojekter - Miljø- og Energiministeriet
Amount: 231,984.00 Danish Kroner

Ydelser for stationære og trackende solfangere

Section for Building Physics and Services
Department of Civil Engineering
Period: 09/10/2009 → 31/12/2009
Number of participants: 2
Project participant:
Nielsen, Elsabet Nomonde Noma (Intern)

Project Manager, organisational:
Furbo, Simon (Intern)

Financing sources
Source: Sam.arb.aftaler, Private danske - Andre virksomheder
Name of research programme: Sam.arb.aftaler, Private danske - Andre virksomheder
Amount: 15,000.00 Danish Kroner

IEA Task 42: Compact Thermal Energy Storage: Material development and System Integration
The project is the Danish part of the first 3 years of the IEA project, International Energy Agency Solar & Cooling Programme Task 42 project "Compact Thermal Energy Storage: Material Development and System Integration". The duration of the IEA project is 4 years. The objective of the project is to develop and demonstrate a compact seasonal heat storage based on a salt hydrate with a stable supercooling. The heat storage can be used as a part of a solar heating system which can fully cover the yearly heat demand of new buildings in Denmark. A seasonal heat storage based on sodium acetate trihydrate will be developed and tested in a laboratory test facility during the IEA project. The development will be divided in a number of separate experimental and theoretical investigations which will elucidate how best to design the heat storage: Among other things answers to the following questions must be found: •Which container materials, container designs and container volumes will result in a stable supercooling of the heat storage material? •Which heat storage temperature level is needed during charge periods in order to achieve a stable supercooling of the heat storage material? •How does the heat storage design influence the heat exchange capacity rate during charge and discharge of the heat storage? Among other things CFD calculations will be applied. •How are large quantities of sodium acetate trihydrate best filled into the containers of a heat storage? •How is the supercooled salt solution activated in the most reliable way? •What is the optimum size of each module consisting of one separate container of the heat storage? •Which control system is most suitable for the heat storage? The operation of the developed heat storage will be simulated as if the heat storage is a part of a solar heating system. A simulation model simulating the thermal performance of the heat storage will be developed and validated by means of the measurements. With the validated model calculations of the
thermal performance of solar heating systems with seasonal heat stores will be carried out in order to determine optimum designs of solar heating systems inclusive seasonal heat stores.

Section for Building Physics and Services

Department of Civil Engineering
Period: 01/01/2009 → 31/12/2011
Number of participants: 4
Project participant:
Fan, Jianhua (Intern)
Nielsen, Elsabet Nomonde Noma (Intern)
Chen, Ziqian (Intern)

Project Manager, organisational:
Furbo, Simon (Intern)

Financing sources
Source: Forskningsprojekter - Miljø- og Energiministeriet
Name of research programme: Forskningsprojekter - Miljø- og Energiministeriet
Amount: 2,664,000.00 Danish Kroner

The two most powerful renewable energy sources are solar and wind energy. It is expected that an increasing part of our electricity consumption in the future will be covered by wind farms. This will result in an increased number of windy periods with a surplus of electricity and thereby a low electricity price. A concept where individual solar heating systems optimised for making use of electricity produced by wind turbines in these periods can facilitate the introduction of wind energy in large scale into the energy system and thereby contribute to increasing the part of our energy consumption covered by renewable energy sources. The heat is produced by the solar heating system and by the electric heating element(s)/heat pump, which, if possible, only should be in operation in periods where the solar heating system cannot fully cover the heat demand and where the electricity price is low, e.g. in windy periods with a high electricity production from wind turbines.

The unit is equipped with a smart heat storage (variable auxiliary volume) and a smart control system based on prognosis for the electricity price, the heat demand of the house, the solar heat production of the solar heating system and weather forecasts. The project will elucidate how best to design an individual heating unit for one family houses based on the above principles. It is also elucidated how suitable the heating unit is for the home owner and for our future energy system. Different designs of the heating unit and the control system will be investigated and the most promising solutions tested experimentally. It is expected that the heating unit is more cost efficient than traditional solar heating systems and that it can be an attractive alternative to oil- and natural gas boilers, both from an economy and environmental point of view.

Section for Building Physics and Services

Department of Informatics and Mathematical Modeling
Department of Mathematics
Period: 01/04/2008 → 31/12/2011
Number of participants: 5
Project ID: 25869

Project participant:
Perers, Bengt (Intern)
Nielsen, Elsabet Nomonde Noma (Intern)
Fan, Jianhua (Intern)
Bacher, Peder (Intern)

Project Manager, organisational:
Furbo, Simon (Intern)

Financing sources
Source: Forskningsrådene - Andre
Name of research programme: Forskningsrådene - Andre
Amount: 7,406,236 Danish Kroner

Project

Solvarmeanlægs energibesparelser, fase 2

Department of Civil Engineering
Period: 17/12/2007 → 31/12/2009
Number of participants: 4
Project ID: 25880

Project participant:
Fan, Jianhua (Intern)
Nielsen, Elsabet Nomonde Noma (Intern)
Schultz, Jørgen Munthe (Intern)

Project Manager, organisational:
Furbo, Simon (Intern)

Financing sources
Source: Forskningsprojekter - Miljø- og Energiminderiet
Name of research programme: Forskningsprojekter - Miljø- og Energiminderiet
Amount: 800,000.00 Danish Kroner

Project

Solvarmeanlægs energibesparelser

Department of Civil Engineering
Period: 29/05/2007 → 31/12/2008
Number of participants: 4
Project ID: 25839

Project participant:
Furbo, Simon (Intern)
Fan, Jianhua (Intern)
Nielsen, Elsabet Nomonde Noma (Intern)
Schultz, Jørgen Munthe (Intern)

Financing sources
Source: Forskningsprojekter - Miljø- og Energiminderiet
Name of research programme: Forskningsprojekter - Miljø- og Energiminderiet
Amount: 700,000.00 Danish Kroner

Project
Proof of Concept, PoC, Inlet stratification device

Department of Civil Engineering
Period: 01/01/2007 → 31/12/2008
Number of participants: 2
Project participant:
Nielsen, Elsabet Nomonde Noma (Intern)
Project Manager, organisational:
Furbo, Simon (Intern)

Financing sources
Source: Forskningsprojekter - Andre ministerier og styrelser
Name of research programme: Forskningsprojekter - Andre ministerier og styrelser
Amount: 716,949.00 Danish Kroner

Solar Thermal Components adapted to common building standards
Pilot versions of a solar heating/natural gas burner system, of a solar heating/pellet burner system and of a façade/roof integrated polymeric collector have been installed in the summer of 2006 in a number of demonstration houses in Denmark, Sweden and Norway. These three new products have been evaluated by means of measurements of the thermal performance and energy savings of the pilot systems in practice and by means of a commercial evaluation. The conclusion of the evaluations is that the products are attractive for the industry partners METRO THERM A/S, Solentek and SOLARNOR. It is expected that the companies will bring the products into the market in 2007. Further, the results of the project have been presented at international and national congresses and seminars for the solar heating branch. The congresses and seminars attracted a lot of interested participants. Furthermore, the project results have been published in international congress papers as well as in national journals in the energy field.

Section for Building Physics and Services
Department of Civil Engineering
University of Oslo
Dalarna University
Riga Technical University
Period: 01/05/2006 → 31/12/2006
Number of participants: 3
Acronym: SCAS
Project ID: 25756
Project participant:
Thür, Alexander (Intern)
Nielsen, Elsabet Nomonde Noma (Intern)
Project Manager, organisational:
Furbo, Simon (Intern)

Financing sources
Source: Forsk. Andre offentlige og private - Nordiske
Name of research programme: Forsk. Andre offentlige og private - Nordiske
Amount: 560,000.00 Danish Kroner

Advanced storage concepts for solar and low energy buildings, IEA-SHC Task 32
The project is the last two years of the Danish participation in the IEA Task 32 project "Advanced storage concepts for solar and low energy buildings". The Danish participation will be focused on Subtask C: Storage concepts based on phase change materials and subtask D: Storage concepts based on advanced water tanks and special devices. In subtask C a laboratory test heat of fusion storage utilizing a stable super cooling of the heat storage material will be tested in the Department's heat storage test facility. Based on the investigations and on cost estimates the potential for heat of fusion storages for solar heating systems with a solar fraction of 100% for low energy buildings will be evaluated. In subtask D experiments are carried out with the aim to elucidate the durability of a new developed fabric inlet stratifier.

Section for Building Physics and Services
Department of Civil Engineering
BASE Consultants S.A.
University of Stuttgart
Graz University of Technology
University of Kassel
SPF Institut fur Solartechnik Prufung Forschung
University of Lleida
Dalarna University
AEE INTEC

Energy Research Centre of the Netherlands
Period: 16/02/2006 → 31/12/2007
Number of participants: 3
Project ID: 25738
Contact person:
Furbo, Simon (Intern)
Project participant:
Nielsen, Elsabet Nomonde Noma (Intern)
Schultz, Jørgen Munthe (Intern)

Financing sources
Source: Forskningsprojekter - Miljø- og Energifondet
Name of research programme: Forskningsprojekter - Miljø- og Energifondet
Amount: 798,000.00 Danish Kroner
Project:

NEGST (Next Generation of Solar Thermal Systems)
Department of Civil Engineering
University of Stuttgart
Hochschule für Technik
Arsenal Research
Nederlandse Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek
SP
Agenzia nazionale per le nuove tecnologie, l’energia e lo sviluppo economico sostenibile
ESTIF
Instituto National de Engenharia e Tecnologia Industrial
DEMOKRITOS
Centre Scientifique et Technique du Bâtiment
Instituto Nacional de Tecnica Aeroespacial
Polytechnic University of Milan
Dalarna University
University of Kassel
Ecofys B.V.
AEE INTEC

University of Oslo
Period: 01/07/2004 → 31/12/2006
Number of participants: 4
Contact person:
Furbo, Simon (Intern)
Project participant:
Fan, Jianhua (Intern)
Shah, Louise Jivan (Intern)
Nielsen, Elsabet Nomonde Noma (Intern)

**Financing sources**

Source: Forsk. EU - Rammeprogram  
Name of research programme: Forsk. EU - Rammeprogram  
Amount: 270,000.00 Danish Kroner

**IEA Task 32: Advanced storage concepts for solar thermal systems in low energy buildings**

University Library  
Technical Information Center of Denmark  
Department of Civil Engineering  
University of Stuttgart  
SPF  
Graz University of Technology  
Dalarna University  
Advanced Energy Economy  
Period: 20/02/2003 → 31/12/2005  
Number of participants: 8  
Contact person:  
Drück, Harald (Ekstern)  
Project participant:  
Nielsen, Elsabet Nomonde Noma (Intern)  
Schultz, Jørgen Munthe (Intern)  
Vogelsanger, Peter (Ekstern)  
Streicher, Wolfgang (Ekstern)  
Bales, Chris (Ekstern)  
Weiss, Werner (Ekstern)  
Project Manager, organisational:  
Furbo, Simon (Intern)

**Financing sources**

Source: Forskningsprojekter - Miljø- og Energiministeriet  
Name of research programme: Forskningsprojekter - Miljø- og Energiministeriet  
Amount: 2,129,000.00 Danish Kroner

**Kombinerede solvarmeanlæg til nemvarme og opvarmning af brugsvand**

Department of Civil Engineering  
Period: 01/08/2001 → 15/08/2007  
Number of participants: 4  
Phd Student:  
Nielsen, Elsabet Nomonde Noma (Intern)  
Main Supervisor:  
Furbo, Simon (Intern)  
Examiner:  
Karlsson, Björn Olof Harry (Ekstern)  
Vajen, Klaus (Ekstern)

**Financing sources**

Source: Internal funding (public)  
Name of research programme: DTU-lønnet stipendie  
Project: PhD
DANISH/SWISS RESEARCH COOPERATION ON SOLAR HEATING SYSTEMS

The aim of the project is to establish a basis for future development of solar heating systems, both solar domestic hot water systems, SDHW systems, and solar heating systems combined for space heating and domestic hot water supply. The project will be carried out in cooperation between Department of Buildings and Energy and SPF, Solartechnik Prüfung Forschung, Rapperswil, Switzerland. The project consists of three parts:
1. CFD CALCULATIONS FOR COMBI STORES
2. SMART SOLAR TANKS
3. INFORMATION ON HIGH PERFORMANCE SDHW SYSTEMS

Department of Buildings and Energy

SPF Institut fur Solartechnik Prüfung Forschung
Period: 08/12/1999 → 28/02/2001
Number of participants: 3
Project participant:
Shah, Louise Jivan (Intern)
Nielsen, Elsabet Nomonde Noma (Intern)

Project Manager, organisational:
Furbo, Simon (Intern)

Financing sources
Source: Unknown
Name of research programme: Ukendt
Amount: 430,000.00 Danish Kroner

Large low flow solar heating system with a smart solar tank and pump

A large solar heating system based on two sections, one facing west and one facing east, will be built at "Sundparken" in Helsingør. Each section will have a collector area of 168 m². The solar tank will be a 10000 l with three different stratification manifold arrangements. These arrangements are designed in such a way that the thermal stratification in the tank is built up in the best possible way. Therefore it is expected that the thermal performance will be very high for the system. A monitoring system for the system will be installed so that it is possible to follow the operation of the system and to measure the thermal performance.

Department of Buildings and Energy

Department of Civil Engineering

Rådgivende ingeniør firma A/S
Period: 31/05/1999 → 30/09/2000
Number of participants: 5
Project participant:
Nielsen, Elsabet Nomonde Noma (Intern)
Shah, Louise Jivan (Intern)
Vejen, Niels Kristian (Intern)
Duer, Vagn (Ekstern)

Project Manager, organisational:
Furbo, Simon (Intern)

Financing sources
Source: Unknown
Name of research programme: Ukendt
Amount: 277,500.00 Danish Kroner

Solar Energy Center Denmark

A number of activities in different fields were carried out:
SIMULATION PROGRAMMES:-A state of the art of solar energy programmes developed and used by Solar Energy Center Denmark was worked out.-Simulation programmes for solar domestic hot water systems were built out so that a flexible variable hot water consumption could be simulated. The programmes were further developed so that the mixing occuring in the solar tank during hot water tapping could be simulated.-A plan for future activities on simulation programmes for Solar Energy Center Denmark was worked out. TEST METHODS:-Existing test methods for solar tanks were evaluated. Based on this improved test methods for the future were worked out.-Investigations on mixing in solar tanks during hot water tapping were carried out.-Existing test methods for evacuated tubular solar collectors were evaluated. Based on this recommendations for future testing of evacuated tubular solar collectors were worked out.-Existing simulation programmes were evaluated by means of measurements for different solar domestic hot water systems in a test facility.

ASSISTANCE FOR THE SOLAR ENERGY BRANCH:-Investigations of
a solar heating system based on the natural gas burner/solar tank-unit Block Gas Sol was carried out. The investigations were carried out for the company Baxi A/S. Development of an ideal solar tank. This work was carried out for the company AquaHeat I/S. Test of a solar collector with and without an antireflection treated glass as cover. This investigation was carried out for Sunarc A/S.

SOLAR ENERGY TECHNOLOGIES: Different solar energy technologies were evaluated with regard to energy savings, costs, durability, energy pay back time etc.

Department of Buildings and Energy
Rise National Laboratory for Sustainable Energy
Department of Civil Engineering
Danish Technological Institute
Period: 01/01/1999 → 31/12/1999
Number of participants: 5
Project participant:
Duer, Karsten (Intern)
Shah, Louise Jivan (Intern)
Nielsen, Elsabet Nomonde Noma (Intern)
Vejen, Niels Kristian (Intern)
Project Manager, organisational:
Furbo, Simon (Intern)

Financing sources
Source: Unknown
Name of research programme: Ukendt
Amount: 1,050,000.00 Danish Kroner

Smart solar tank
The aim of the project is to show that small SDHW systems can have improved cost/performance ratio if a smart solar tank is used as the heat storage. A smart solar tank is a small tank with an external pipe loop from the bottom to the top of the tank. Heat is supplied to the pipe loop by the auxiliary energy supply system. This heat is transferred to the top of the tank by means of the fluid in the pipe loop. The operation of the auxiliary energy supply system is controlled by the hot water demand, the consumption pattern, the energy content and the thermal stratification in the top of the tank. Two differently designed smart solar tanks will be tested in a heat storage test facility. Mathematical models which simulate the thermal behaviour of the tanks, will be developed. The models will be validated by means of the tests. Based on the investigations improved designed smart solar tanks will be developed and built into two small SDHW test systems which will be tested in a laboratory test facility and in practice. Measurements and experience from the systems will elucidate the suitability of the different smart solar tanks.

Department of Buildings and Energy
Period: 12/02/1998 → 31/12/2000
Number of participants: 2
Project participant:
Nielsen, Elsabet Nomonde Noma (Intern)
Project Manager, organisational:
Furbo, Simon (Intern)

Financing sources
Source: Unknown
Name of research programme: Ukendt
Amount: 580,000.00 Danish Kroner

Test methods for solar DHW tanks
Different test methods for SDHW tanks have been evaluated. Both experimental and theoretical investigations have been carried out. A marketed solar tank has been tested in a heat storage test facility. The yearly thermal performance of solar heating systems with the tested solar tank has been calculated. The measured and calculated results have been compared to results obtained by the solar energy test laboratory in Rapperswil, Switzerland and results from TI, Tästrup. Based on the investigations new test methods have been proposed.

Department of Buildings and Energy
Danish Technological Institute
Solar energy systems
The aim of the project is to develop solar energy systems. Research have been carried out in different fields in order to improve our knowledge of the systems. The activities will shortly be described in the following: -In cooperation with Kildemoes Solvarme a heat storage for a combined solar heating system for both space heating and domestic hot water supply was developed. The heat storage was tested in an indoor heat storage test facility. -A number of small SDHW systems (Solar Domestic Hot Water systems) have been tested in the Institute's test facility for solar heating systems. Both test systems and marketed systems - for instance a system marketed by Batec A/S - have been tested. -Theoretical work with a detailed computer model simulating the thermal behaviour of low flow systems have been carried out. The aim was to investigate how the attractive low flow SDHW systems are best designed. - Work with the aim to follow the activities going on abroad in the field of R&D on solar heating plants have been carried out. -Laboratory tests concerning heat storage in a concrete wall have been carried out. The aim was to improve our knowledge concerning the thermal behaviour of walls utilizing passive solar energy.

Department of Buildings and Energy
Kildemoes Solvarme
BATEC A/S

Solar heating systems
The aim of the project is to develop solar heating systems and components for solar heating systems. Different projects are carried out in cooperation with manufacturers within the solar energy branch. -Development of a solar tank/natural gas boiler-unit for Nilan A/S. -Investigations connected to development of a solar heating/wood burner system based on the drain back principle for Nellemann, Nielsen & Rauschenberger A/S, HSTarm and Ar-Con Solvarme A/S. -Investigations of the thermal behaviour of the Kombiterm GE hot water tank with a circulation piping for Kahler & Breum Beholder- og Maskinfabrik K/S. -Investigation of thermal bridges in solar collectors. -Investigation of rain tight problems for solar collectors on stands. -Investigations of the thermal behaviour of mantle tanks. -Measurements of the thermal performance of small SDHW systems in the Institute's test facility for solar heating systems. - Development of a simple test method for solar tanks for SDHW systems.
Department of Buildings and Energy  
Period: 01/01/1997 → 31/12/1997  
Number of participants: 6  
Project participant:  
Shah, Louise Jivan (Intern)  
Vejen, Niels Kristian (Intern)  
Heuer, Andreas Walter (Intern)  
Nielsen, Elsabet Nomonde Noma (Intern)  
Holck, Ole (Intern)  
Project Manager, organisational:  
Furbo, Simon (Intern)

Financing sources  
Source: Unknown  
Name of research programme: Ukendt  
Amount: 1,000,000.00 Danish Kroner

Activities:

Building and Environment (Journal)  
Period: 30 Nov 2011 → 30 Dec 2011  
Elsabet Nomonde Noma Nielsen (Reviewer)  
Department of Civil Engineering  
Section for Building Physics and Services  
Related journal

Building and Environment  
Local database  
Activity: Research › Peer review of manuscripts

ISES Solar World Congress 2011 (Journal)  
Period: 22 Mar 2011 → 20 Apr 2011  
Elsabet Nomonde Noma Nielsen (Reviewer)  
Department of Civil Engineering  
Section for Building Physics and Services  
Related journal

ISES Solar World Congress 2011  
Local database  
Activity: Research › Peer review of manuscripts

Syns- og skønserklæring, B-1906-07: Vedr. varmtvandsforsyning til ejerlejlighed - Ejerforeningen Løvparken ff od Ulla og Lasse Sørensen  
Period: 1 Jan 2009 → …  
Elsabet Nomonde Noma Nielsen (Other)  
Department of Civil Engineering  
Section for Building Physics and Services  
Description

Coordinated by Elsa Andersen  
Related external organisation

Strubjerg 382, 9400 Nørresundby
Activity: Other