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Zusammenfassung

Von 2010 bis 2014 wurden im Rahmen des Solar Heating and Cooling Task 44 / Heat Pump Programme Annex 38 (Task 44 / Annex 38) der Internationalen Energieagentur (IEA) Forschungsarbeiten im Bereich "Solar and Heat Pump Systems" koordiniert. Die Arbeiten waren aufgeteilt in die Subtasks:

- Subtask A: Solutions and generic systems
- Subtask B: Performance assessment
- Subtask C: Modelling and simulation
- Subtask D: Dissemination and market support

Die Leitung des Subtask C wurde anfänglich vom Solar Energy Research Center in Schweden - SERC (Chris Bales) übernommen. Nach dem KickOff Meeting im April 2010 wurde die Leitung vom SERC auf Grund mangelnder Finanzierung abgegeben, und in der Folge dem SPF Institut für Solartechnik übertragen und durch Michel Haller wahrgenommen. Die Hauptziele, welche im Subtask C verfolgt und erreicht wurden, sind:

1. Thermodynamische Analyse von Systemen mit zwei Wärmequellen
2. Die Definition gemeinsamer Randbedingungen für Klima und Lasten, welche es ermöglichen, Simulationsresultate unterschiedlicher Simulationstools und unterschiedlicher Forschungsgruppen miteinander zu vergleichen
3. Validierung und gegebenenfalls Anpassung von Komponentenmodellen für die Simulation von Solar-Wärmepumpen-Systemen – auch im Hinblick auf seriell verschaltete Systeme.
4. System-Simulationen und Validierung derselben mit Messdaten. Erkenntnisse über die System-Performance von Solar-Wärmepumpen-Systemen sowie die eventuellen Vorteile von seriell verschalteten Systemen.
5. Erarbeiten / Entwickeln von Software-Tools für die Auslegung von Systemen.

Die Arbeiten des Subtask C wurden vom SPF Institut für Solartechnik koordiniert und in enger internationaler Zusammenarbeit ausgeführt, unter anderem auch durch Arbeitsgruppen zu einzelnen Themen welche sich auch ausserhalb der IEA Task Meetings engagierten. Die erfolgreiche internationale Zusammenarbeit führte zu mehr als 60 Konferenzbeiträgen und 40 öffentlichen Präsentationen, davon 50% (Konferenzbeiträge) und 78% (Präsentationen) mit Schweizer Beteiligung. Weiter trug der Subtask C wesentlich bei zu Publikationen in peer reviewed journals, Doktorarbeiten, und der Entwicklung von Softwaretools.

Eine ausführliche Dokumentation der Arbeiten und Publikationen findet sich in den Berichten welche für die IEA fertiggestellt wurden (vgl. <http://task44.iea-shc.org/>), insbesondere:

- C1 – The Reference Framework for System Simulations
- C2 – Models of Sub-Components and Validation
- C3 – System Simulation Reports
- C4 – Synthesis of System Simulation Results
- C5 - Dissemination Activities of Subtask C

Die wichtigsten Ergebnisse wurden in zwei Kapiteln eines aus dem Task 44 / Annex 38 entstandenen Handbooks zusammengefasst, welches ab Herbst 2014 bei Wiley erhältlich sein wird. Insgesamt wurde der Subtask C von den Task Teilnehmern als überdurchschnittlich aktiv und erfolgreich beurteilt.

Abstract

From 2010 to 2014 the Solar Heating and Cooling Task 44 / Heat Pump Programme Annex 38 (Task 44 / Annex 38) of the International Energy Agency (IEA) coordinated research and development in the field of "Solar and Heat Pump Systems". This work was structured into the Subtasks:

- Subtask A: Solutions and generic systems
- Subtask B: Performance assessment
- Subtask C: Modelling and simulation
- Subtask D: Dissemination and market support

The coordination of Subtask C was originally attributed to the Solar Energy Research Center in Sweden - SERC (Chris Bales). After the Kick-Off meeting in April 2010 the Subtask leadership of SERC was discontinued due to lack of resources, and taken over by the SPF Institut für Solartechnik (Michel Haller). The main targets that were pursued and reached within this subtask were:

1. Thermodynamic analysis of systems with two heat sources
2. The definition of common boundary conditions for climates and loads for the simulation of solar and heat pump systems that enable to compare simulation results obtained with different simulation platforms and from different research groups.
3. Validation and improvement of component models for the simulation of solar heat pump systems, in particular also for series connected system approaches or systems with ground regeneration.
4. System simulation and validation with measured data. Creation of knowledge about the performance of solar and heat pump systems and the possible advantages of series connected systems.
5. Creation of software tools for the design and sizing of components and systems.

The work of Subtask C was coordinated by SPF and carried out in close collaboration with the international participants of the Task/Annex. Working groups were established that worked together on specific topics also beyond the Task meetings. The successful collaboration led to more than 60 conference papers and 40 public presentations, thereof 50% (conference papers) and 78% (presentations) with Swiss contributions. Furthermore, Subtask C has contributed to peer reviewed journal articles, PhD Thesis, and the development of software tools.

An extensive documentation and summary of the work can be found in the reports that were written for the IEA (<http://task44.iea-shc.org/>), these are in particular:

- C1 – The Reference Framework for System Simulations
- C2 – Models of Sub-Components and Validation
- C3 – System Simulation Reports
- C4 – Synthesis of System Simulation Results
- C5 - Dissemination Activities of Subtask C

The main findings were also summarized in two chapters for the Handbook on Solar and Heat Pump Systems that is a result of the IEA SHC Task 44 / Annex 38 and will be published by Wiley in autumn 2014. Overall, subtask C has been classified as extraordinarily active and successful by the Task participants.

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1 Summary

The work in Subtask C of the IEA SHC Task 44 / HPP Annex 38 was coordinated by the Institut für Solartechnik SPF and the work was carried out in close cooperation with the international partners. The coordination included the preparation and lead of the Subtask sessions in the eight project meetings. Additionally, national workshops were organized twice per year in Switzerland where the Swiss participants of Task 44 / Annex 38 presented and discussed their work.

2 Working Groups and Task Reports

For a more effective coordination of the large variety of issues to be investigated on an international level, working groups were established within Subtask C with internationally renowned experts (see Annex A) on the following specific topics:

- Boundary Conditions and Platform Independence
- Collectors / Collector Models
- Heat Pumps / Heat Pump Models
- Ground Heat Exchange
- Storage (including PCM)

These experts contributed also significantly to the technical Subtask C reports:

C1 – The Reference Framework for System Simulations

C2 – Models of Sub-Components and Validation

C3 – System Simulation Reports

C4 – Synthesis of System Simulation Results

C5 - Dissemination Activities of Subtask C

Some of these reports comprise several parts that have been written in separate documents. For a full list of all reports, sub-reports and authors see Annex B.

3 Most important results and findings

The boundary conditions for simulation of solar and heat pump systems that were defined in Report C1 have been implemented on four different simulation platforms (TRNSYS, Polysun, Matlab/Simulink and IDA-ICE) and have not only been used extensively within the past years, but continue to be used by the international research community.

The most important findings of Subtask C have been summarized in two chapters of the Task Handbook that will be published by Wiley in 2014:

- Chapter 3 - **Components and Thermodynamic Aspects**, M.Y. Haller, E. Bertram, R. Dott, T. Afjei, F. Ochs, D. Carbonell, A. Heinz, C. Sunliang, K. Siren, approx. 25 pages.
- Chapter 7 - **System Simulations**, M. Y. Haller, D. Carbonell, E. Bertram, A. Heinz, C. Bales, F. Ochs, approx. 34 pages.

Important inputs have also been provided and parts written for other chapters of the handbook, in particular:

- Chapter 5 - **Laboratory test procedures for solar and heat pump systems**
- Chapter 6 - **Monitoring**

More detailed information is also available free of charge in several technical reports of Subtask C available from <http://task44.iea-shc.org/publications> as soon as the reviewing process by the IEA is finished.

4 Additional Publications and Dissemination

Additional publications and dissemination activities that are based on the work of Subtask C are listed in Annex C. These include more than 60 conference papers, of which 20 were also oral presentations, four publications in peer reviewed journals, more than 20 additional presentations of Task, several project reports, PhD Thesis, and software tools.

Annex A Working Groups of Subtask C

A.1 Boundary Conditions and Platform Independence

Michel Haller*	michel.haller@solarenergy.ch	SPF	CH
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A.3 Heat Pumps / Heat Pump Models

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A.4 Ground Heat Exchange

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A.5 Storage (including PCM)

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Annex B Subtask Reports and Authors List

Table 1: Completed reports of subtask C, including their status.

Nr.	Title	Authors	Date	Status
C1 part A	The Reference Framework for System Simulations of the IEA SHC Task 44 / HPP Annex 38 - Part A: General Simulation Boundary Conditions	M.Y. Haller, R. Dott, J. Rutschenburg, F. Ochs, J. Bony	8 Nov. 2013	Final Rev.
C1 part B	The Reference Framework for System Simulations of the IEA SHC Task 44 / HPP Annex 38 - Part B: Buildings and Space Heat Load	R. Dott, M.Y. Haller, J. Rutschenburg, F. Ochs, J. Bony	6. Sep. 2013	Final Rev.
C2 part A	Models of Sub-Components and Validation for the IEA SHC Task 44 / HPP Annex 38 - Part A: Summary	M. Y. Haller, E. Bertram, R. Dott, T. Afjei, F. Ochs, C. Sunliang, K. Siren, J.-C. Hadorn	7 March 2013	Final
C2 part B	Models of Sub-Components and Validation for the IEA SHC Task 44 / HPP Annex 38 - Part B: Collector Models	E. Bertram, D. Carbonell, B. Perers, M.Y. Haller, M. Bunea, S. Eicher	23 Nov. 2012	Final
C2 part C	Models of Sub-Components and Validation for the IEA SHC Task 44 / HPP Annex 38 - Part C: Heat Pump Models	R. Dott, T. Afjei, A. Genkinger, A. Dalibard, D. Carbonell, R. Consul, A. Heinz, M. Haller, A. Witzig, J. Facão, F. Ochs, P. Pärisch	10 June 2013	Final
C2 part D	Models of Sub-Components and Validation for the IEA SHC Task 44 / HPP Annex 38 - Part D: Ground Heat Exchangers	F. Ochs, D. Carbonell, M. Haller	16 Oct. 2013	Final
C2 part E	Models of Sub-Components and Validation for the IEA SHC Task 44 / HPP Annex 38 - Part E: Storage Models	S. Cao, K. Siren, A. Heinz, S. Bonk	8 Nov. 2013	Final
C3	System Simulation Reports for the IEA SHC Task 44 / HPP Annex 38	M.Y. Haller ¹	11 March 2014	Final Draft ²
C4	Intercomparison of System Simulation Results for the IEA SHC Task 44 / HPP Annex 38	M.Y. Haller, D. Carbonell, E. Bertram, A. Heinz, C. Bales	1 May 2014	Final Draft ³
C5	Dissemination Activities of Subtask C of the IEA SHC Task 44 / HPP Annex 38	M.Y. Haller	28 April 2014	Final

¹ With contributions from E. Bertram, I. Mojic, R. Dott, W. Lerch, D. Carbonell, M. Bunea, C. Winteler, F. Ochs, J. Bony, M. D'Antoni, J. Facão, A. Heinz, P. Hollmuller, B. Perers, M. Bättschmann, P. Kurmann, M.R. Collins, J. Chu, T. Fassnacht, D. Zenhäusern.

² for reviewing by the Exco.

³ for reviewing by the Exco.

Annex C Other Publications and Dissemination

A.6 Reports

The following project reports with material that was based on Subtask C work have been reported to the Subtask C leadership:

Mermoud, F., Frage, C., Hollmuller, P., Pampaloni, E., Lachal, B., 2014: ***COP5 : Source froide solaire pour pompe à chaleur avec un COP annuel de 5 généralisable dans le neuf et la rénovation***, Rapport final, 2014, Université de Genève, Office fédéral de l'énergie OFEN, Bern.

Haller, M.Y., Haberl, R., Carbonell, D., Philippen, D., Frank, E., 2014. ***SOL-HEAP - Solar and Heat Pump Combisystems***. Final report, Institut für Solartechnik SPF, Swiss Federal Office of Energy (SFOE), Bern.

Bertram, E., Pärish, P., Mercker, O., Arnold, O., Tepe, R. & Rockendorf, G., 2014. ***Hocheffiziente Wärmepumpensysteme mit Geo- und Solarthermie-Nutzung***. ISFH, Hameln.

A.7 Journal Articles

Due to the time-consuming efforts for the preparation and the reviewing process, articles in peer reviewed journals appear always with a certain time delay. It is thus expected that this list is not exhaustive, and that further articles will be published based on work of Subtask C of T44A38 within the coming years:

Facão, J. & Carvalho, M.J., 2014. *New test methodologies to analyse direct expansion solar assisted heat pumps for domestic hot water*. *Solar Energy*, 100, p.66–75.

Pärish, P., Mercker, O., Warmuth, J., Tepe, R., Bertram, E. & Rockendorf, G., 2014. *Investigations and model validation of a ground-coupled heat pump for the combination with solar collectors*. *Applied Thermal Engineering*, 62(2), p.375–381.

Gustafsson, M., Dermentzis, G., Myhren, J.A., Bales, C., Ochs, F., Holmberg, S. & Feist, W., *Energy performance comparison of three innovative HVAC systems for renovation through dynamic simulation*. *Energy and Buildings* (in press, accepted manuscript).

Pichler, M.F., Lerch, W., Heinz, A., Goertler, G., Schranzhofer, H. & Rieberer, R., 2014. *A novel linear predictive control approach for auxiliary energy supply to a solar thermal combistorage*. *Solar Energy*, 101, p.203–219.

A.8 Conference Papers

The following is a list of conference papers that have been published in connection with the work of the Subtask C of the IEA SHC Task 44 / HPP Annex 38. **Not** included are:

- publications made prior to the start of Task 44 / Annex 38.
- publications in the field of solar and heat pump systems that did not have any connection with the Task
- publications that do not include modeling and/or simulation of solar and heat pump systems

Conference papers that were at the same time oral presentations are **highlighted**.

- Afjei, T. & Dott, R., 2011. **Heat pump modelling for annual performance, design and new technologies.** In Proc. of the Building Simulation (BS) Conference 2011, Sydney, AU.
- Afjei, T., Dott, R. & Genkinger, A., 2012. **Wärmepumpe und Solarthermie – Kurzberichte zu den Projekten SOFOWA und EFKOS.** In: News aus der Wärmepumpen-Forschung - 19. Tagung des BFE-Forschungsprogramms "Wärmepumpen und Kälte," Burgdorf, Switzerland.
- Bertram, E., 2014. **Solar Assisted Heat Pump Systems with Ground Heat Exchanger – Simulation Studies.** Energy Procedia, 48, p.505–514.
- Bertram, E., Glembin, J. & Rockendorf, G., 2012. **Unglazed PVT collectors as additional heat source in heat pump systems with borehole heat exchanger.** Energy Procedia, Volume 30, p.414–423.
- Bertram, E., Glembin, J., Scheuren, J. & Rockendorf, G., 2010. **Condensation Heat Gains on Unglazed Solar Collectors in Heat Pump Systems.** In: Proc. of the EuroSun 2010 Conference, Graz, Austria.
- Bertram, E., Glembin, J., Scheuren, J. & Zinterra, G., 2009. **Soil regeneration by unglazed solar collectors in heat pump systems.** In: Proc. of the ISES Solar World Congress 2009, Johannesburg, South Africa.
- Bertram, E., Pärtsch, P. & Tepe, R., 2012. **Impact of solar heat pump system concepts on seasonal performance - Simulation studies.** Proceedings of Eurosun 2012, International Solar Energy Society (ISES)-Europe Solar Conference, Rijeka Croatia, p.ID 37.
- Bertram, E., Pärtsch, P. & Tepe, R., 2013. **Solare Wärmepumpensysteme mit Erdwärmesonden-Konzeptvergleiche.** In: Proceedings 12. Internationales Anwenderforum Oberflächennahe Geothermie, OTTI e.V., Neumarkt i. d. Oberpfalz, Germany.
- Bertram, E., Pärtsch, P. & Tepe, R., 2013. **Solare Wärmepumpensysteme mit Erdwärmesonde - Konzeptvergleich von Systemvarianten.** In: Proceedings 23. Symposium Thermische Solarenergie, OTTI e.V., Bad Staffelstein.
- Bertram, E., Stegmann, M. & Rockendorf, G., 2011. **Heat Pump Systems with Borehole Heat Exchanger and Unglazed PVT Collector.** In: Proceedings of the ISES Solar World Congress 2011,
- Bunea, M., Eicher, S., Hildbrand, C., Bony, J., and Citherlet, S. (2012). **Test de couplage d'une pompe à chaleur avec collecteur solaire thermique.** In Proc. of the Symposium ER'12, (Yverdon-les-Bains, Switzerland).
- Bunea, M., Eicher, S., Hildbrand, C., Bony, J., Perers, B., and Citherlet, S. (2012). **Performance of solar collectors under low temperature conditions: Measurements and simulations results.** In Proc. of the EuroSun 2012 Conference, (Rijeka and Opatija, Croatia).
- Carbonell, D., Cadafalch, J., Pärtsch, P. & Consul, R., 2012. **Numerical Analysis of Heat Pump Models. Comparative Study Between Equation-Fit and Refrigerant Cycle Based Models.** In: Proc. of the EuroSun 2012 Conference, Rijeka and Opatija, Croatia.
- Carbonell, D., Haller, M.Y., Philippen, D. & Frank, E., 2014. Simulations of Combined Solar Thermal and Heat Pump Systems for Domestic Hot Water and Space Heating. Energy Procedia, 48, p.524–534.
- Carbonell, D., Philippen, D., Haller, M.Y., Frank, E., 2013. **Development and validation of a mathematical model for ice storages with heat exchangers that can be de-iced.** In: Proc. of the ISES Solar World Congress 2013, Cancun, Mexico.
- D'Antoni, M., Ferruzzi, G., Bettoni, D. & Fedrizzi, R., 2012. **Validation of the numerical model of a turnkey solar combi + system.** Energy Procedia, 30, p.551–561.
- Dott R. & Afjei T. 2013. **System evaluation of combined solar & heat pump systems.** In Proc. of Cisbat 2013 Conference, 4.-6. September, Lausanne, CH.

- Dott, R., Afjei, T. & Genkinger, A. 2013. **System evaluation of combined solar & heat pump systems.** In Proc. of Clima 2013 Conference, 16.-19. June, Prague, CZ.
- Dott, R., Afjei, T. & Genkinger, A. 2013. **Systemvergleich von kombinierten Solar- und Wärmepumpensystemen.** In: 23. Symposium Thermische Solarenergie, 24. - 26. April, OTTI Regensburg, Bad Staffelstein, Germany, CD.
- Dott, R., Genkinger, A. & Afjei, T., 2012. **System evaluation of combined solar & heat pump systems.** In: **Solar Heating and Cooling (SHC) Conference 2012**, San Francisco, USA.
- Dott, R., Genkinger, A., Moret, F. & Afjei, T., 2011. **Combining heat pumps with solar energy for domestic hot water production.** In: 10th IEA Heat Pump Conference 2011, Tokyo, JP.
- Eicher, S., Hildbrand, C., Bony, J., Bunea, M., Hadorn, J.-C. & Citherlet, S., 2012. **Solar Assisted Heat Pump for Domestic Hot Water Production.** Energy Procedia, 30, p.571–579.
- Eicher, S., Hildbrand, C., Kleijer, A., Bony, J., Bunea, M. & Citherlet, S., 2014. **Life Cycle Impact Assessment of a Solar Assisted Heat Pump for Domestic Hot Water Production and Space Heating.** Energy Procedia, 48, p.813–818.
- Genkinger, A., Dott, R. & Afjei, T., 2012. **Combining heat pumps with solar energy for domestic hot water production.** In: Solar Heating and Cooling (SHC) Conference 2012,
- Haller, M.Y. & Frank, E., 2010. **Kombination von Wärmepumpen mit solarthermischen Kollektoren - Konzepte und Fragestellungen.** In: CD - Konferenzbeiträge 16. Status-Seminar "Forschung und Bauen im Kontext von Energie und Umwelt", 2./3. Sep., BRENET - Nationales Kompetenznetzwerk Gebäudetechnik und erneuerbare Energien, ETH Zürich, 1–6.
- Haller, M.Y. & Frank, E., 2011. **On the Potential of Using Heat from Solar Thermal Collectors for Heat Pump Evaporators.** In: Proc. of the ISES Solar World Congress 2011, Aug. 28 - Sep. 2, Kassel, Germany.
- Haller, M.Y. & Frank, E., 2011. **Steigert die Nutzung von Solarkollektoren als Wärmequelle für Wärmepumpen die System-Arbeitszahl?** In: 21. Symposium Thermische Solarenergie, 11. - 13. Mai, OTTI Regensburg, Bad Staffelstein, Germany, CD.
- Haller, M.Y., Bertram, E., Dott, R., Afjei, T., Ochs, F. & Hadorn, J.-C., 2012. **Review of Component Models for the Simulation of Combined Solar and Heat Pump Heating Systems.** Energy Procedia, 30, p.611–622.
- Haller, M.Y., Haberl, R., Mojic, I. & Frank, E., 2014. **Hydraulic Integration and Control of Heat Pump and Combi-storage: Same Components, Big Differences.** Energy Procedia, 48, p.571–580.
- Haller, M.Y., Carbonell, D., Mojic, I., Winteler, C., Bertram, E., Bunea, M., Lerch, W. & Ochs, F., 2014. **Solar and Heat Pump Systems – Summary of Simulation Results of the IEA SHC Task 44/HPP Annex 38.** In: Proc. of the 11th IEA Heat Pump Conference, Montreal, Canada.
- Haller, M.Y. & Frank, E., 7.-9. Mai. **Solarwärme & Wärmepumpen – Interpretation der Simulationen des IEA SHC Task 44 / HPP Annex 38.** In: 24. OTTI Symposium Thermische Solarenergie, OTTI e.V., Regensburg, Kloster Banz, Bad Staffelstein, Germany.
- Heinz, A.; Lerch, W.: **Kombination Solarthermie / Wärmepumpe inkl. Abwasserwärmerückgewinnung: Energetische Bewertung verschiedener Systeme durch dynamische Anlagensimulationen.** 22. Symposium Thermische Solarenergie, 09.-11.05.2012, Bad Staffelstein, DE, Tagungsband S. 182 – 183.
- Joyce, A., Coelho, L., Martins, J.F., Tavares, N., Pereira, R. & Magalhães, P., 2011. **A PV/T and Heat Pump based trigeneration system model for residential applications.** In: ISES Solar World Congress, 28 August - 2 September, 2011, Kassel, Germany.

- Kurman, P., 2011. **Optimierung der Einbindung eines 28m³-Wasserspeichers in die Beheizung und die WW-Versorgung mit WP und Solarthermik.** In: News aus Wärmepumpen- Forschung und -Markt, 29. Juni 2011, Burgdorf, Switzerland.
- Lerch, W., Heinz, A., Fink, C., Bredler, J. & Wagner, W., 2011. **Kombination Solarthermie / Wärmepumpe inkl. Abwasser-Wärmerückgewinnung (AWR).** In: 21. OTTI Symposium Thermische Solarenergie, 11. - 13. Mai 2011, Kloster Banz, Bad Staffelstein, Germany.
- Lerch, W.; Heinz, A.: **Kombination von Solarthermie und Wärmepumpe inkl. Abwasserwärmerückgewinnung.** RENEXPO AUSTRIA 2011, 3. Österreichisches Wärme-pumpen Forum. Salzburg am 24.11.2011.
- Lerch, W.; Heinz, A.: **Solare Wärmepumpen- Kombianlagen inkl. Abwasser Wärmerückgewinnung: Energetische Bewertung durch dynamische Anlagensimulationen in TRNSYS.** Gleisdorf Solar 2012 – 10. Internationale Konferenz für thermische Solarenergienutzung, 12. – 14. September 2012, Gleisdorf, AT, Tagungsband S. 212 – 221.
- Lerch, W.; Heinz, A.; Thür, A.; Vukits, M.: **Optimierung von Solar-Wärmepumpen-Kombianlagen anhand von dynamischen Anlagensimulationen.** - in: Tagungsband 22. Symposium Thermische Solarenergie. (2012), S. 186 – 187
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A.9 Additional Presentations

Table 2 lists presentations of Subtask C work in addition to the presentations that were given at conferences already listed above.

Table 2: Presentations held on Subtask C topics with dissemination beyond the task members.

Date	Event & Place	Title	<u>Presenter & Authors</u>
2011-04-06	Industry Workshop of the IEA SHC Task 44 / HPP Annex 38, Barcelona, Spain	Simulation of Combined Solar and Heat Pump Systems: What can be done before a project?	<u>M. Haller</u>
2011-06-08	2. VDI Konferenz Wärmepumpen, Frankfurt a. M., Germany, 8.6.2011	Wärmepumpensystem mit solarthermisch unterstützten Erdwärmesonden	<u>E. Bertram</u>
2012-05-02	Industry Workshop of the IEA SHC Task 44 / HPP Annex 3, Povoia de Varzim, Portugal	Modeling & Simulation of Solar and Heat Pump Systems	<u>M. Haller</u>
2012-05-02	Industry Workshop of the IEA SHC Task 44 / HPP Annex 38, Povoia de Varzim, Portugal	Heat Pump Modelling	R. Dott, T. Afjei
2011-06-29	Wärmepumpen-Tagung, Burgdorf, CH	SOFOWA – Kombination von Solarthermie, Fotovoltaik und Wärmepumpe	<u>T. Afjei</u> , R. Dott, A. Genkinger
2011-10-27	4. Norddeutsche Geothermietagung, Hannover, Germany, 27.10.2011	Solar- und Geothermie - ideale Partner für hohe Jahresarbeitszahlen!	<u>R. Tepe</u>
2012-03-21	SPF Industrietag, Rapperswil, Switzerland	Kombination von Solarthermie mit Wärmepumpen	M.Haller, D. Philippen <u>R. Haberl</u>
2012-03-29	Swissolar ERFA WP-Solar on, Muttenz, Switzerland	Kombination von Solarthermie mit Wärmepumpen	<u>M.Haller</u> , D. Philippen <u>R. Haberl</u>
2012-06-27	Wärmepumpen-Tagung, Burgdorf, CH	Wärmepumpe und Solarthermie – Kurzberichte zu den Projekten SOFOWA und EFKOS	<u>T. Afjei</u> , R. Dott, A. Genkinger
2012-04-04	Swissolar ERFA WP-Solar, Buchs, Switzerland	Kombination von Solarthermie mit Wärmepumpen	<u>M.Haller</u> , D. Philippen <u>R. Haberl</u>
2012-12-10	Informationsveranstaltung "Effiziente Solar- und Wärmepumpenkonzepte", Hannover, Germany, 10.12.2012	Measurement and simulation results for the combination of solar collectors and GCHP systems	<u>E. Bertram</u> , <u>P. Pärtsch</u> , <u>R. Tepe</u> , <u>G. Rockendorf</u>
2013-01-23	Sonnen-Symposium, Graz, Austria	Kombination von Solarthermie mit Wärmepumpen	<u>M.Haller</u>
2013-01-31	3. Deutsche Solarthermie-Technologiekonferenz, Berlin, Germany, 31.01.2013	Experimentelle Untersuchungen an erdgekoppelten Wärmepumpen	<u>G. Rockendorf</u>
2013-	SPF Industrietag, Rapperswil, Switzerland	Anbindung von Wärmepumpen an	<u>M.Haller</u> , <u>R. Haberl</u>

03-14	land	Kombispeicher	
2013-04-08	Industry Workshop of the IEA SHC Task 44 / HPP Annex 38, Mechelen, Portugal	Hydraulic Integration of Heat Pumps with Combistores	<u>M. Haller</u> , R. Haberl, I. Mojić, A. Reber
2013-04-18	SolPumpEff Abschluss-Workshop "Solarthermie und Wärmepumpenkombinationen - Heizsysteme der Zukunft?", Wels, Austria	Solare Kombispeicher mit Wärmepumpe – Details entscheiden über die Performance	<u>M.Haller</u> , R. Haberl
2013-06-26	Wärmepumpen-Tagung Burgdorf, CH	Integration von Kombispeichern in Solar-Wärmepumpenanlagen	<u>M.Haller</u> , R. Haberl
2013-06-26	Wärmepumpen-Tagung, Burgdorf, CH	Wärmepumpen, Photovoltaik und Eisspeicher - Anforderungen an erfolgreiche Systeme	<u>T. Afjei</u> , R. Dott, C. Winteler
2013-11-20	ISFH Industrietag, Emmerthal, Germany, 20.11.2013	Erdgekoppelte solar unterstützte WP-Systeme: Konzepte – Methoden – Lösungen	<u>R. Tepe</u>
2013-11-23	BauHolzEnergie-Messe Bern, CH	Neuheiten und Innovationen mit Wärmepumpen – Wärmepumpe mit Solar-Eisspeicher	<u>T. Afjei</u> , C. Winteler, R. Dott
2014-03-19	SPF Industrietag, Rapperswil, Switzerland	Wärmepumpe und Solarwärme: Vermeintliche und tatsächliche Synergien	<u>M.Haller</u> ,
2014-05-12	HPP Annex 38 Workshop at the International Heat Pump Conference, Montreal, Canada	Solar and Heat Pump Systems – Summary of simulation results of the IEA SHC Task 44 / HPP Annex 38	<u>M.Haller</u> ,

A.10 Software Tools

Software-tools that are available to the public either for free or for sale:

Haller, 2012. TRNSYS Type 832 v5.00 „Dynamic Collector Model by Bengt Perers“ - Updated Input-Output Reference, Institut für Solartechnik SPF, Hochschule für Technik HSR, Rapperswil, Switzerland. <http://www.spf.ch/?id=223>, Accessed: Dec. 4 2012.