Cologne Institute for Renewable Energy

Technology
Arts Sciences
TH Köln

Newsletter

September 2022

Master Erneuerbare Energien – Master Renewable Energy Management – Bachelor Erneuerbare Energien – Bachelor Elektrotechnik / Studienrichtung Elektrische Energietechnik

Update on CIRE's Project Solardachpfanne.NRW - Decentralized Power and Heat Supply Made in NRW

Figure 1. Solar Roof Tile equipped test roof [Picture: Münzberg, paXos Consulting & Engineering GmbH & Co. KG]

In the project Solardachpfanne.NRW, the concept of solar thermal energy was implemented technologically in combination with photovoltaics, which achieves a high level of functional integration (storm suction protection, automatic shutdown in the event of a fire, ...). The aim of the project was to research the technological basics in order to develop and optimize the Solar Roof Tile (SRT) in such a way that it can later be mass-produced and used like a conventional roof tile.

The solar roof tile must have numerous characteristics such as high energy efficiency, heat resistance, mechanical robustness, a very long service life, recyclability and fire protection. During the development phase, the focus was on both the individual solar roof tiles and the overall system, i.e. the series connection of several solar roof tile modules. With the completion of the development phase, the prototype construction, as well as another conventional reference roof area, is now in a one-year measurement phase. In this year, the performance of the system will be examined in a comparable, realistic duration test to evaluate the profitability for different consumer profiles with regard to optimal operating strategies of the SRT (see Figure 1). Additionally, aging and wear can also be examined as well.

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Solar Roof Tile (SRT) At-A-Glance:

- ✓ ***Visually attractive and easy installation on the roof surface***
- ✓ ***High hail-, storm- and access-resistance***
- ✓ ***Fireproof according to VKF standard***
- ✓ ***Combination of PV and solar thermal with heat pump possible***
- ✓ ***High energy efficiency***

1) Constructional implications for the roof component (Prof. Ruth Kasper)

To determine the mechanical robustness and load behavior of the solar roof tile, CAD simulations were used to simulate relevant load cases in advance, such as walking on the roof surface or hailstorms (Figure 1.1). Roof slopes, glass thicknesses, product specifications of the materials and temperature dependencies were investigated.

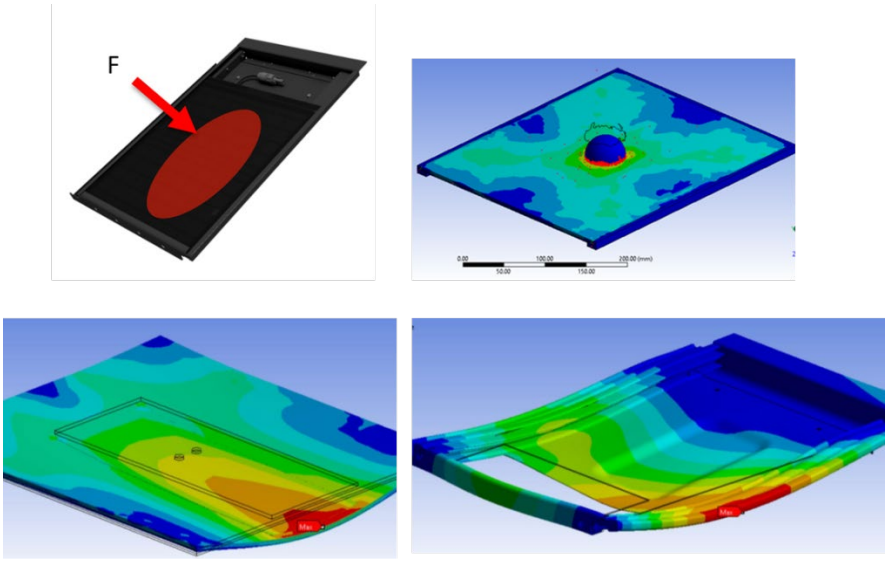

Figure 1.1. Simulated forces in the glass under different loading conditions such as accessing (bottom) and hail (top right) [Pictures: Recinos Tabora & Kasper, both TH Köln]

Figure 1.2 shows an example of how these results were verified in laboratory tests and also examined for electrical performance under mechanical load of the solar cells.

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Figure 1.2. Load tests in laboratory setup [Pictures: Recinos Tabora & Kasper, both TH Köln]

2) Optimization of the solar coupling through optical and thermal analysis of the solar roof tile (Prof. Ulf Blieske)

To optimize the solar coupling, the optical losses at the SRT were first analyzed at different reflection curves ("Incidence Angle Modifier") in an experimental setup (Figure 2.1). This allowed the optical losses to be minimized by optimal glass and material selection.

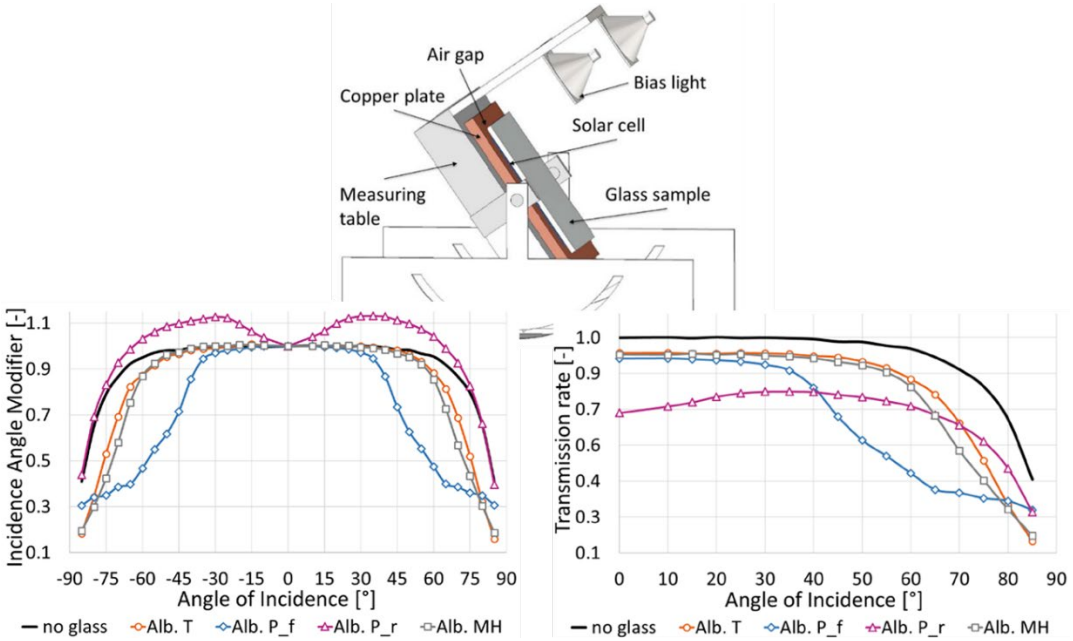

Figure 2.1. Measurements of the relative angle-dependent reflection curves of different glass covers without (left) and with (right) consideration of the transmittance [Picture: Clasing, TH Köln]

Fluid models, coupled with energy models, were used to determine an optimal combination of cell and roof tile types. The usage of dissipation heat of the SDP in combination with a heat pump was also systemically analyzed detailed (Figure 2.2).

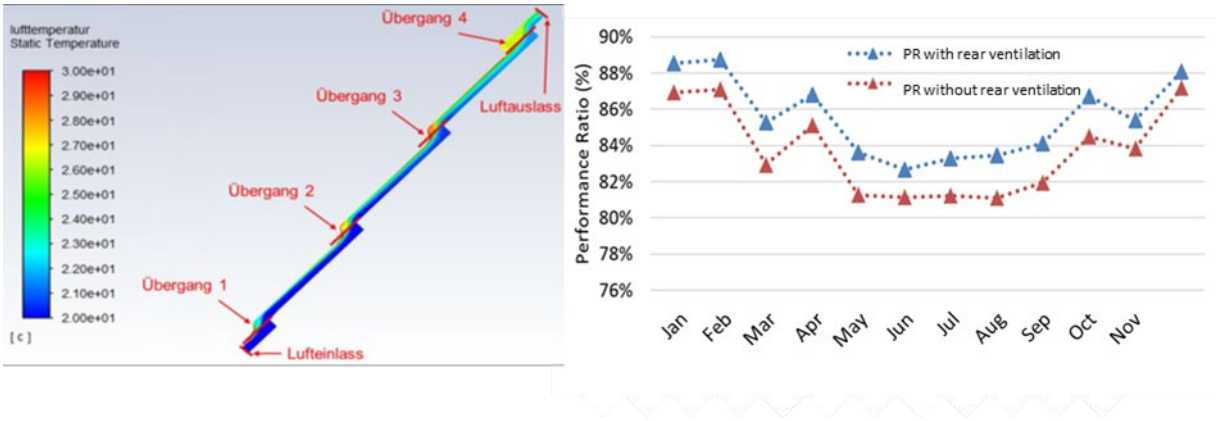

Figure 2.2. Temperature distribution with active ventilation in the fluid channel (left) and simulated performance ratio of the cooled and uncooled SRT over the year (right) [Picture: Clasing, TH Köln]

3) Energy concepts, socio-economic study, ecological & economical Potential Analysis (Prof. Eberhard Waffenschmidt)

For the development and evaluation of energy concepts with the solar roof tile, a model of the energy system was built, taking topological degrees of freedom into account (Figure 3.1). As input data, test reference years for the solar cells as well as heat demand profile of the house were used to determine optimized operation strategy of the energy and cooling system. E.g. for an operation with heat pump and thermal storage.

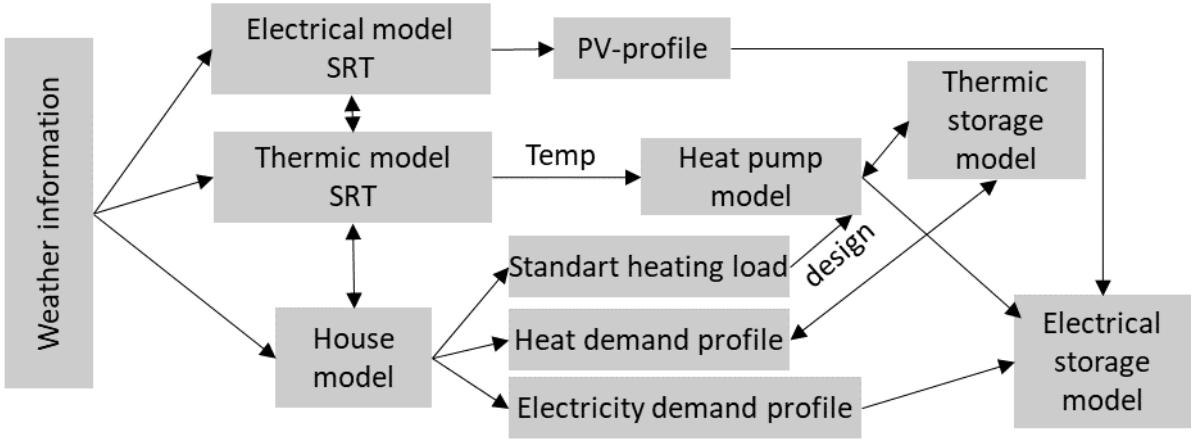

Figure 3.1. Schematic view of the used energy model [Picture: Brosig, TH Köln]

Figure 3.2 shows the percentage difference between the COP of the heat pump with and without SRT and illustrates possible improvements in the COP, which can be increased by about 23%.

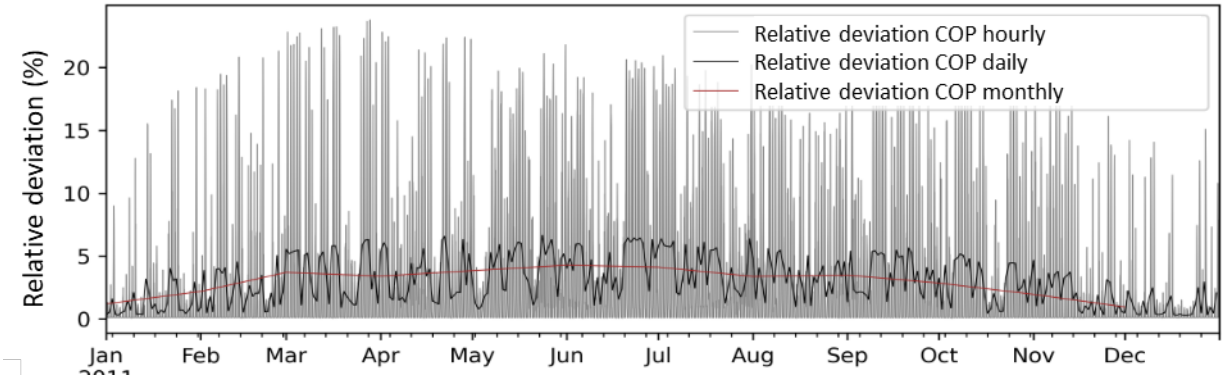

Figure 3.2. Percentage deviation between the COP of the heat pump with and without SRT [Picture: Brosig, TH Köln]

In addition, the integration into a "smart home" system, the legal classification with regard to applicable laws and the possibilities of certifications such as cradle-to-cradle (C2C) were studied.

4) Optimization of the electrical system topology both systemically up to the grid feed and in a roof tile (Prof. Christian Dick)

The test roof is equipped with two different strings, one equipped with standard junction box (Figure 4.1, left), one equipped with a micro-converter, acting as MPP tracker (Figure 4.1, right). Besides robustness and safety features, the micro-converter can increase the efficiency of the overall system by compensating mismatches like partial shading.

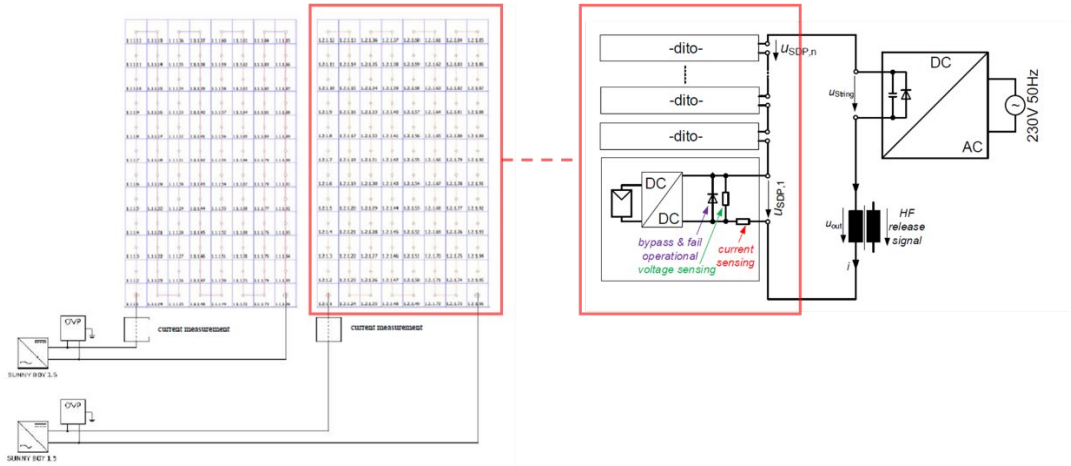

Figure 4.1. Test roof including 2 strings with 96 roof tiles each (left) and principle of the applied micro-converter (right) [Pictures: Jöntgen & Dick, both TH Köln]

The major design goal for this integrated converter are low costs at high energy efficiency and low power consumption. A reduced clock frequency of the microcontroller of 5 Mhz minimizes the power consumption to 75 mW. An efficiency of up to 98 % is achieved, even under unfavorable circumstances (for example heavy partial shading), the efficiency is still above 85 % (Figure 4.2).

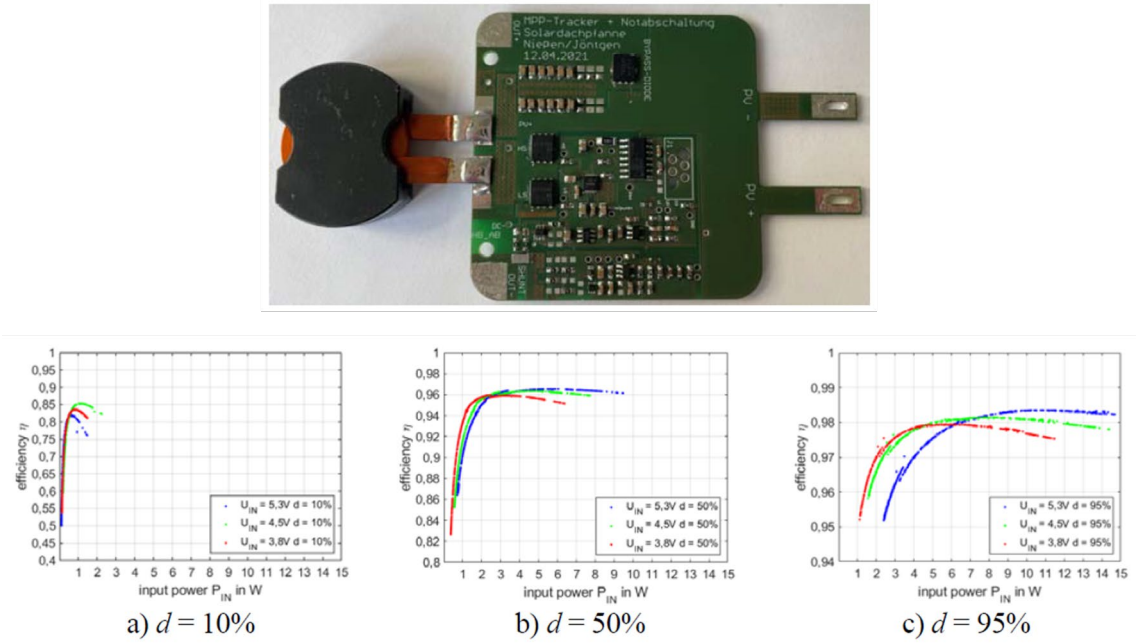

Figure 4.2. Implemented roof-tile integrated step-down converter (top) and Measured converter efficiencies (bottom) [Pictures: Nießen, TH Köln]

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Update on CIRE's Project MEergie

As part of the MEnergie project, some CIRE professors and employees were actively involved in the topic of plug-in solar in the months of May, June and July 2022.

Photos: Tobias Rehm, CIRE TH Köln and Anne Karrenbrock, CoCo TH Köln

First there was a stand at the Nacht der Technik on June 10th in Cologne. A PV module, inverters and an explanatory poster were on display. The great interest in photovoltaics and the fundamentally positive attitude towards this technology was clearly noticed here.

On 15th June a plug-in solar workshop for bachelor-students of the Code & Context, TH Köln with Ulf Blieske and Stefanie Könen-Sagui took place at the Mülheim campus. A total of four plug-in solar workshops at Campus Deutz with Eberhard Waffenschmidt and in cooperation with the VDE and Sascha Birk followed the 23rd and 24th of June.

After 45 minutes of theory, small groups of participants were able to put a plug-in solar system into operation. For this practical part, PV modules, inverters, shelly-plug smart

sockets were provided. The workshop material was borrowed from Professor Stolz from the VDE and the Koblenz University of Applied Sciences.

Plug-In-PV is particularly challenging for citizens in terms of purchase, registration, secure attachment and operationalization. Experts are needed to accompany. There is an interest in understanding how much power the plug-in solar device can achieve. An overview of flat-rate values for generation and information on kilowatt hours, costs and CO2 emissions are desired. People often do not have a feeling for electricity costs and their consumption or the electricity need of individual household appliances.

The staff involved in the Plug-In project agreed that the dense and clear presentation of the most important facts and reliable sources on a poster was very well received.

CIRE's new project

Professor May and Professor Rhein will start the project "Einfache nachhaltige Werkzeuge fürMINT-Grundlagen (EnaWeMI)"

With their teaching concept "simple sustainable tools for MINT fundamentals" Professor Johanna Friederike May (Institute of Electrical Power Engineering) and Professor Beate Rhein (Institute of Communications Engineering) provide for a more sustainable use of computers.

In MINT subjects specialized software is needed, e.g. numerical mathematical programs. Therefore, many students buy new computers, but not all students can afford that. This issue increases inequality between students and buying new computers leads to a higher energy and resource consumption. May and Rhein want to integrate openly accessible web tools into their teaching that can work on all computers. The project collects existing web based programs, generates helpful examples for those who teach in higher ed and develops exercises that use sustainability examples.

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CIRE's new project

The new research project Quirinus-Control has been running since the beginning of June. The aim of the project is to measure and monitor the quality of the power grid in the Rhineland region. The imminent discontinuation of lignite-fired power plants and the steady expansion of wind and solar energy raise the question of whether the quality of the grid will continue to be maintained to the necessary extent for local industry and commercial enterprises. A scientific project has now been initiated for this purpose, involving the TH Cologne, RWTH Aachen University, several scientific institutes and electricity grid operators. Prof. Ingo Stadler and Prof. Eberhard Waffenschmidt are involved in the project, which will run for four years, as well as Patrick Mack as a research assistant. Another research assistant is still being recruited.

Link: https://www.quirinus-control.de/

CIRE's Interview about SolAhrtal on Focus-Online

Rebuilding the Ahrtal after the flood

Link: https://www.focus.de/perspektiven/flutreporter/ein-jahr-nach-der-flut-kein-solahrtal-lueckenhaftes-bundesgesetz-bremst-nachhaltigen-wiederaufbau_id_113879682.html

CIRE's project Smart Metering in KMU

Intelligent energy measuring systems for small businesses

Link: https://www.th-koeln.de/hochschule/mehrwerte-intelligenter-messsysteme-fuer-kleine-und-mittlere-unternehmen_95129.php

One of CIRE's student projects with Professor Stenzel

Standortanalyse des Bundesstützpunkts Mülheim

Link: https://www.badminton.de/news/badminton/dbv-und-seine-partner-starten-standortanalyse-des-bundesstuetzpunkts-muelheim/

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Student field trips

On June 3rd, 2022, a group of students from the Bioenergy and Regenerative Gas Technology course in the Renewable Energies Bachelor's degree, led by Professor Dr. Stenzel, visited the biogas plant of AVG Kompostierung GmbH at the Cologne site. The AVG plant provides processed biomethane for feeding into the natural gas grid from biowaste from household waste collection. After the tour of the biogas plant and the biomethane processing plant, the biomethane feed-in station of RNG / Rheinenergie could also be visited in perfect sunshine. The CIRE would like to thank the companies involved for the very interesting excursion.

On June 24th, 2022, a group of students from the Bioenergy and Regenerative Gas Technology course in the Renewable Energies Bachelor's degree, led by Professor Dr. Stenzel and Dipl.-Ing. Thomas Mockenhaupt, the Leppe landfill of the Bergische Abfallwirtschaftsverband (BAV) with the teaching and research site :metabolon of the TH Cologne and the BAV. In addition to the visit to the research halls with the topics of biomass combustion, biogas production, thermochemical material conversion and leachate treatment, the visit to the biogas plant and the composting plant of avea GmbH was the focus of the excursion.

Photos: Peter Stenzel, TH Köln

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Student field trips

Excursion to Donaueschingen-Aasen for measuring Albedo

One mandatory part of the renewable energy master program is the so called 'Masterproject', where students must work on a topic of their choice (of a given selection) for two semesters. Our group's topic is the validation of a simulation tool for large scale bifacial photovoltaic yield (BifacialSimu), developed by a phD student of the TH Köln. Therefore, we had to collect yield data of large scale bifacial pv plants and compare the data to the simulated yield. Getting access to suitable yield data of pv plants, that fitted our requests was probably the hardest part of the whole project, but we finally found a 4,1 MWp vertical fixed tilt power plant in Donaueschingen-Aasen, Baden-Württemberg which's operators gave us access to the yield data.

The simulation tool needs different input parameters, for example irradiance data, size of the pv plant, specific module characteristics and ground albedo values. The closer the given input parameters represent the actual present conditions, the better are possible simulation results. To not only use literature values for the albedo of the grass in between the pv panels (which also gets mowed from time to time, additionally affecting its reflectivity) we decided to measur e the albedo on site.

Therefore, we planned an excursion to the pv plant, to install pyranometers for albedo measurement. After a five hour drive we arrived at the pv plant which was actually the largest pv plant we have ever seen and also the

first one, using a vertical east-west orientation of the modules resulting in a flatter yield curve. We got a short instruction about the plant and discussed, where to install the pyranometers for the most representative measurement values. Installing and levelling the pyranometer in the burning midday sun was more complicated than we would have thought. After a few hours of scolding around, trying to mount the pyranometers in a leveled position and meanwhile getting a nice sunburn, we were happy with the positioning.
We hope that the measurement equipment is working properly and the collected data helps us to improve our simulating results!
Photos: Rudorf Gecke, TH Köln (Jorit Hanneforth MA EE, Oliver Pfeiffer MA EE, Christopher Marks MA EE, Rudolf Gecke WMA)

Publications of Interest

Eberhard Waffenschmidt,"Vorteile und Betriebskonzepte von Quartiersspeichern",EW - Magazin für die Energiewirtschaft, Ausgabe 6/2022, S. 22-25, VDE-Verlag, Juni 2022
Link: http://www.100pro-erneuerbare.com/publikationen/2022-06-Waffenschmidt-EW-Magazin/Waffenschmidt-Quartierspeicher.htm

Eberhard Waffenschmidt,"Community Battery Storage",Presentation at International 100% Renewable Energy Conference (IRENEC 2022), online organized in Istanbul, 9.-11. June 2022
Link: http://www.100pro-erneuerbare.com/publikationen/2022-06-Waffenschmidt-IRENEC/Waffenschmidt-Community_Storage.htm

Francisco Carrasco Serrano and Johanna Friederike May"Targeted preprossessing for weight reduction in NILM datasets", IEEE Energycon May 2022 Riga, Latvia
Link:https://ieeexplore.ieee.org/xpl/conhome/9830117/proceeding?isnumber=9830142&searchWithin=carrasco

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Arjuna Nebel et al"The Role of Renewable Energies, Storage and Sector-Coupling Technologies in the German Energy Sector under Different CO2 Emission Restrictions", Sustainability, Volume 14, Issue 16, 10.3390/su141610379
Link: https://www.mdpi.com/2071-1050/14/16/10379

Event of Interest

Online-Conference „Kölnisch H2 – Neues aus der Wasserstoffregion“ of the KölnBusiness Wirtschaftsförderung, HyCologne - Wasserstoff Region Rheinland e.V. and TH Köln on September 29th, 1 p.m. -4 p.m.
Link: https://koeln.business/veranstaltungs-detail/koelnisch-h2-neues-aus-der-wasserstoffregion