IEA SHC Proposed Task: Smart Solar Water Heating for 2030

Taylor, R.A.[1], Guthrie, K.[2], He, T.[3], Li B.[3], Richard Hall[4], Simon Furbo[5], Jianhua Fan[5], Bany Mousa, O.[1]

[1]*School of Mechanical and Manufacturing Engineering, UNSW-Sydney, Kensington, NSW, 2052*
[2]*Sustainable Energy Transformation, Clifton Hill, Victoria, 3068*
[3]*China Academy of Building Research (CABR), Beijing, China, 100013*
[4] *Energy Transitions, Pontypridd, United Kingdom*
[5]*Department of Civil Engineering, Technical University of Denmark, Lyngby, Denmark*

The Background

It is easy to forget that hot water is a critical energy service…until you are forced to take a cold shower! The amount of energy consumed in heating water is also surprisingly large. Due to its high specific heat capacity, heating water for a 10-minute shower requires > 3kWh of heat (assuming a modern <10 L/min. water-efficient fixture and a 30°C temperature boost). Writ large, water heating accounts for ~16% of the primary energy used in residential buildings [1], while buildings represent ~1/3rd of total primary energy consumption [2]. This high energy demand—coupled with the fact that heating and storing hot water is relatively straight-forward—has (historically) enabled solar thermal water heaters to serve as *THE* renewable energy vanguard. In the last 5-10 years, however, wind and photovoltaic (PV) technologies have edged past solar thermal water heaters in terms of installed renewable energy capacity globally.

The Foreground

Looking forward, the global water heating market is steadily growing (e.g., more people are using more hot water each year) [3] and, at the same time, many countries around the world are adopting renewable energy and/or car bon emissions targets and policies [4]. Although it is easy to overlook, almost every country will eventually desire and acquire the means to sustainably produce domestic hot water for its citizens to meet these targets. China, for example, is projected to have the world's largest economy by 2030 [5] *and* it has committed to reaching carbon neutrality by 2060 [6]. At present, ~40% of the energy used in Chinese residential buildings is directed towards hot water heating [7].

The Task's Scope

To investigate the best path(s) forward, Australia and China have jointly proposed to operate an International Energy Agency Solar Heating and Cooling Technology Collaboration Programme Task entitled, "Smart Solar Water Heating for 2030". The proposed Task will focus on two main solar energy pathways: Thermosyphons and PV-driven water heaters. Thermosyphons were selected because they are the most used solar heating system today (57% of the water-based solar heating systems in operation in 2019 [8]), and are expected to play a major role going forward. PV-solar water heaters were selected because they are poised for rapid growth in both lower income regions (without robust gas or electricity supply) and in higher income regions (where water heating can soak up excess PV, rather than exporting it to the grid). Both technologies are relatively robust because they avoid pumped circulation and require minimal maintenance. In addition, both technologies are also rapidly becoming 'smart' with advanced monitoring and control systems which can interface with other household energy systems, learn usage patterns, and generally maximise the value of solar energy production for their owners, along with any enterprising companies which can develop and sell such products. Figure 1 (below) shows schematics of these technologies.

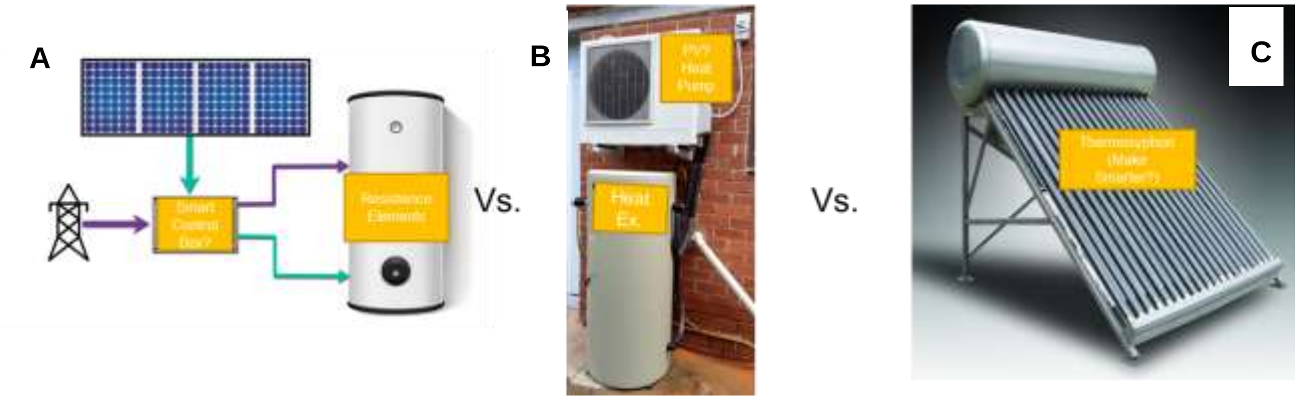

Figure 1. Hot water system options to be considered in the SHC Task: ***A.*** *PV-diverters/solar-smart electric water heater;* ***B.*** *PV-driven Heat Pump;* ***C.*** *Thermosyphon water heater*

The proposed Task will also investigate the existing regulatory/policy frameworks, minimum performance and reliability standards, and commercial potential for smart thermosyphon systems and photovoltaic self-consumption water heaters. This will help ensure these two technologies are truly reliable, affordable, and clean sources of hot water. The proposed Task will also aim to find and propose solutions to bottlenecks to rapid commercial manufacture/supply of these solar water heater technologies in different regions across the world (building upon prior SHC Task knowledge/expertise). Moreover, the proposed Task will investigate the potential advantages/disadvantages of deploying '*smart*' systems to integrate *solar thermal thermosyphon syst*ems and *PV self-consumption* systems with other energy systems, noting that there is potential for 'smart' technologies which offer little or negative value to consumers/society. Finally, in addition to investigating the most technologically and economically viable solutions, the proposed Task will also assess the 'lowest carbon' options—including the carbon embodied in manufacturing the thermosyphon and photovoltaic water heater systems, which is a function of the carbon intensity of the energy input during fabrication, along with the seasonal variations during the usage phase, and the end-of-life carbon impacts.

Subtask Organisation

The final organization of the subtasks will be agreed after discussion with other interested parties. However, the following subtask breakdown will be discussed at our Task Development Workshop 23-34 September:

Subtask A*: State-of-the-art and operating environments in different regions*

- Data collection/comparison on regional hot water loads
- Installed technologies and backup fuels used
- Identification of barriers to adoption (technological, economic, social)
- Outline of currently available market support programs
- Identification of relevant regional targets (i.e., RE heating targets)

Subtask B*: Smart Thermosyphon systems*

- Design options to minimize conventional fuel boosting
- System sizing for load
- Design tools and existing standards
- Installation requirements
- Smart control systems

***Subtask C**: PV self-consumption systems, including smart controls*

- Design options to minimize conventional fuel boosting
- System sizing for load (grid vs. off-grid)
- Design tools and existing standards
- Installation requirements (including best practices for retrofitting)
- Smart control systems (available products and future developments)

***Subtask D:** Training and standards*

- Training needs
- Standards for performance evaluation and durability (i.e., Solar Keymark)

Conclusions

In summary, this proposed Task represents a collaborative, international effort between researchers, industry, and testing laboratories to identify and implement opportunities to improve the performance of the solar water heaters of the future. Although other technologies are available, our focus will be on thermosyphon systems and PV water heaters, which we believe will have the highest level of adoption across the broad, global range of meteorological climate zones and economic development. We also aim for the proposed task to assist local technology rollouts and to cross-fertilize development globally. However, for this Task to be successful we are actively seeking experts from the APSRC community to help identify market opportunities, add technical knowledge, and to help us identify and solve key issues with these technologies. With the help of APSRC, and other international experts, we are confident we help guide the market for Smart Solar Hot Water Heating for 2030.

References

[1] IEA, Shares of residential energy consumption by end use in selected IEA countries, 2018, IEA, Paris https://www.iea.org/data-and-statistics/charts/shares-of-residential-energy-consumption-by-end-use-in-selected-iea-countries-2018.

[2] Global British Petroleum (2021). "Energy Outlook 2020 edition". https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/energy-outlook/bp-energy-outlook-2020.pdf . (Accessed 26/07/2021).

[3] Research and Markets. "Global Water Heaters Market Report 2021: Long-term Forecasts to 2025 & 2030". Available from: https://www.globenewswire.com/en/news-release/2021/06/16/2247970/28124/en/Global-Water-Heaters-Market-Report-2021-Long-term-Forecasts-to-2025-2030.html. (Accessed 1/08/2021).

[4] Ahmed SF, Khalid M, Vaka M, Walvekar R, Numan A, Rasheed AK, Mubarak NM. Recent progress in solar water heaters and solar collectors: A comprehensive review. Thermal Science and Engineering Progress. 2021:100981.

[5] PwC (2017). "The World in 2050, the long view: how will the global economic order change by 2050?". Available from: https://www.pwc.com/gx/en/world-2050/assets/pwc-the-world-in-2050-full-report-feb-2017.pdf . (Accessed on 2/8/2021).

[6] García-Herrero A, Tagliapietra S. China has a grand carbon neutrality target but where is the plan? Bruegel-Blogs. 2021:NA.

[7] Cao X, Dai X, Liu J. Building energy-consumption status worldwide and the state-of-the-art technologies for zero-energy buildings during the past decade. Energy and buildings. 2016;128:198-213.

[8] Werner Weiss, Monika Spörk-Dür. Solar Heat Worldwide: Global Market Development and Trends in 2020, detailed Market Data 2019. (2021).