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An Energy and Economic Comparison of Solar Thermal Collectors for Domestic Hot Water Applications

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Abstract : Today, the global solar thermal market is dominated by two collector types; the flat plate and evacuated tube collector. With regards to the number of installations worldwide, the evacuated tube collector is the dominant variant primarily due to the Chinese market but the flat plate collector dominates both the Australian and European markets. The market share of the evacuated tube collector is, however, growing in Australia due to a common belief that this collector type is 'more efficient' and, therefore, the better choice for hot water applications. In this study, we investigate this issue further to assess the validity of this statement. This was achieved by methodically comparing the performance and economics of several solar thermal systems comprising of; a low-performance flat plate collector, a high-performance flat collector, and an evacuated tube collector coupled with a storage tank and pump. All systems were simulated using the commercial software package Polysun for four climate zones in Australia to take into account different weather profiles in the study and subjected to a thermal load equivalent to a household comprising of four people. Our study revealed that the energy savings and payback periods varied significantly for systems operating under specific environmental conditions. Solar fractions ranged between 58 and 100 per cent, while payback periods range between 3.8 and 10.1 years. Although the evacuated tube collector was found to operate with a marginally higher thermal efficiency over the selective surface flat plate collector due to reduced ambient heat loss, the high-performance flat plate collector outperformed the evacuated tube collector on thermal yield. This result was obtained as the flat plate collector possesses a significantly higher absorber to gross collector area ratio over the evacuated tube collector. Furthermore, it was found for Australian regions operating with a high average solar radiation intensity and ambient temperature, the lower performance collector is the preferred choice due to favorable economics and reduced stagnation temperature. Our study has provided additional insight into the thermal performance and economics of the two prevalent solar thermal collectors currently available. A computational investigation has been carried out specifically for the Australian climate due to its geographic size and significant variation in weather. For domestic hot water applications were fluid temperatures between 50 and 60 degrees Celsius are sought, the flat plate collector is both technically and economically favorable over the evacuated tube collector. This research will be useful to system design engineers, solar thermal manufacturers, and those involved in policy to encourage the implementation of solar thermal systems into the hot water market.

Keywords : solar thermal, energy analysis, flat plate, evacuated tube, collector performance
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