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A new tool for assessing the performance of Transpired Solar Collectors used for solar ventilation pre-heating

Richard Hall[a], Andy Allen[b]

[a]*Welsh School of Architecture, Cardiff University, Bute Building, King Edward VII Ave, Cardiff , CF10 3NB, Wales*
[b]*Tata Steel, Shotton Works, Deeside, Flintshire, CH5 2NH, Wales*

Abstract

Transpired Solar Collectors (TSCs) are an increasingly popular technology, with over 12,500 m^2 of TSCs integrated with buildings across Wales and England by the end of 2013. But in order for TSCs to achieve the desired low economic and embodied energy payback periods, their design, manufacture, installation and commissioning needs to be seamlessly integrated with that of the building as a whole. To facilitate the selection and integration of a TSC in the earliest stages of building design, a new feasibility tool for Transpired Solar Collectors has been developed. The new tool enables a full feasibility assessment to be carried out in less than five minutes, and its user-friendly methodology and interface allows it to be used by building designers who have little or no experience in designing solar thermal collectors. Comparative research presented in this paper demonstrates that the tool's feasibility engine provides similar energy performance results to the RETScreen® V3.1 Solar Air Heating Project Model. In addition, the new tool automatically calculates the building's heating demand and is able to consider the impact of internal gains (solar and occupancy), collector tilt, and low emissivity coatings. The new tool is not intended to replace the role of more sophisticated, dynamic modelling and simulation tools which the expert user and building energy assessor would be expected to use for the detailed design of a TSC. The new tool is currently being evaluated on commercial projects in the UK and is set to be available across Europe in early 2015.

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1. Introduction

In 2012, the global operational solar air heating capacity was estimated to be around 1.6 GW_{th} (2.3 million square meters) [1, p. 11], accounting for a mere 0.6 % of the solar thermal market. But more recently a number of the world's largest steel makers have begun manufacturing Transpired Solar Collectors (TSCs) [2], [3], a type of once-

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through solar air heater, and the installed capacity is expected to grow rapidly as TSCs become an almost standard component in new industrial steel buildings. Since the introduction of TSCs in to the UK in 2005, over 12,500 m^2 of collectors have been installed [4], which are estimated to be generating around 3 GWh of renewable heat each year.

TSCs are predominately used to pre-heat a building's ventilation air supply by drawing the outside air through a solar heated perforated sheet [5, 6]. As the outside air (ventilation supply air) passes through the micro-perforations in the collector sheet, heat is transferred by convection from the relatively higher temperature solar heated metal sheet to the relatively colder outside air [7, pp. 285–287]. By raising the temperature of the ventilation air supply to a temperature that is nearer to the building's indoor temperature, the heating demand of the building is reduced (when no heating is required, the ventilation air supply bypasses the TSC). In the UK, solar pre-heating of a building's ventilation air supply with TSCs has "the potential to make a *significant contribution* to both the heating and overall energy consumption of a typical low energy distribution centre" [8, p. 6].

In order for TSCs to achieve the lowest possible economic payback periods, the design, manufacture, installation and commissioning of the TSC needs to be seamlessly integrated with that of the building as a whole. Early in the design of the building there are two key characteristics of the TSC that need to be considered:

1. the area of the TSC collector; and
2. an estimate of the energy savings that could be achieved.

The current best practice tool for determining these characteristics is the National Resources Canada RETScreen® International Solar Air Heating Project Model Version 3.1 (SAH3) [9 - 11]. But the accurate determination of the values for "fraction of month used" (located on the 'Solar Resources' tab of the SAH3 spreadsheet) in this SAH3 tool can be open to personal interpretation. These values, one for each month of the year, determine what proportion of the heat generated by the TSC can be considered to reduce the heating demand of the building.

Rather than inputting the "fraction of month used" based on the previous experience of the practitioner or with the assistance of a secondary building modelling tool, a more objective approach would be for the software to make an representative assessment of the heating demand of the building based on the location and characteristics of the building. Creating this improved method for determining the "fraction of month used" was one of the main requirements in the development of the new software tool for assessing the performance of Transpired Solar Collectors used for solar ventilation pre-heating.

Nomenclature

Q	Quantity of Heat	MJ
A	Area	m^2
η	Gain utilisation factor/efficiency	-
I	Irradiance	MJ/m^2

2. New feasibility software tool for Transpired Solar Collectors

2.1. Objectives

As well as further developing the method for determining the "fraction of month used", the other objectives of creating the new feasibility tool were to:

- make it usable by non-TSC specialists;
- be based on international standards;
- be able to record and retrieve previously undertaken feasibility studies;
- be able to generate a feasibility report (in PDF format) in under 5 minutes.

To achieve these objectives, a tool based around the EN ISO 13790:2008 'Energy performance of buildings -- Calculation of energy use for space heating and cooling' [12] monthly single-zone quasi-steady-state calculation methodology has been developed.