Solar Roofing System Thermal Performance Analysis

Beyond Today's Infrastructure

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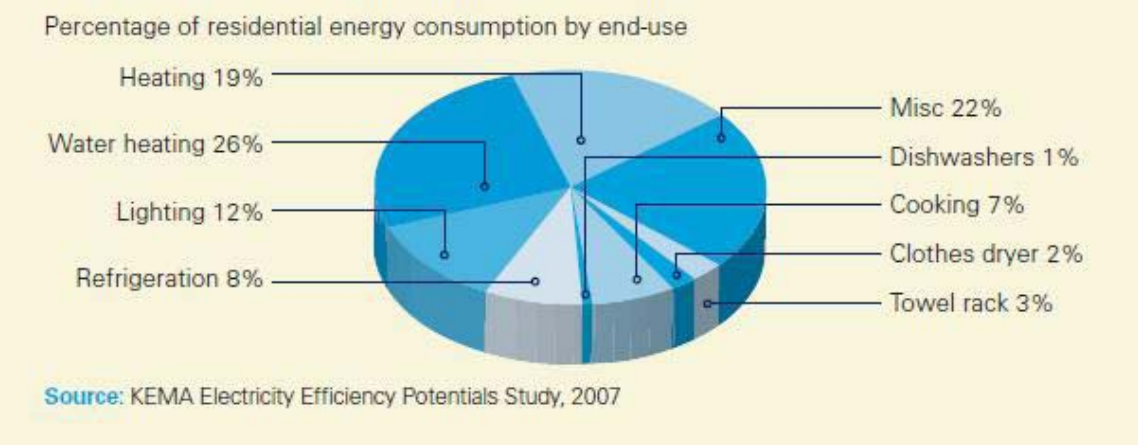
Roofing System in NZ & Australia

Long Run Metal Roof

•In NZ and Australia long run metal roofing is widely used for domestic, commercial and industrial applications.

•In NZ, an average house rooftop of 150m^2 collects 2.2 x 10^8 Wh/year ie. 20 to 30 times the house's total requirements.

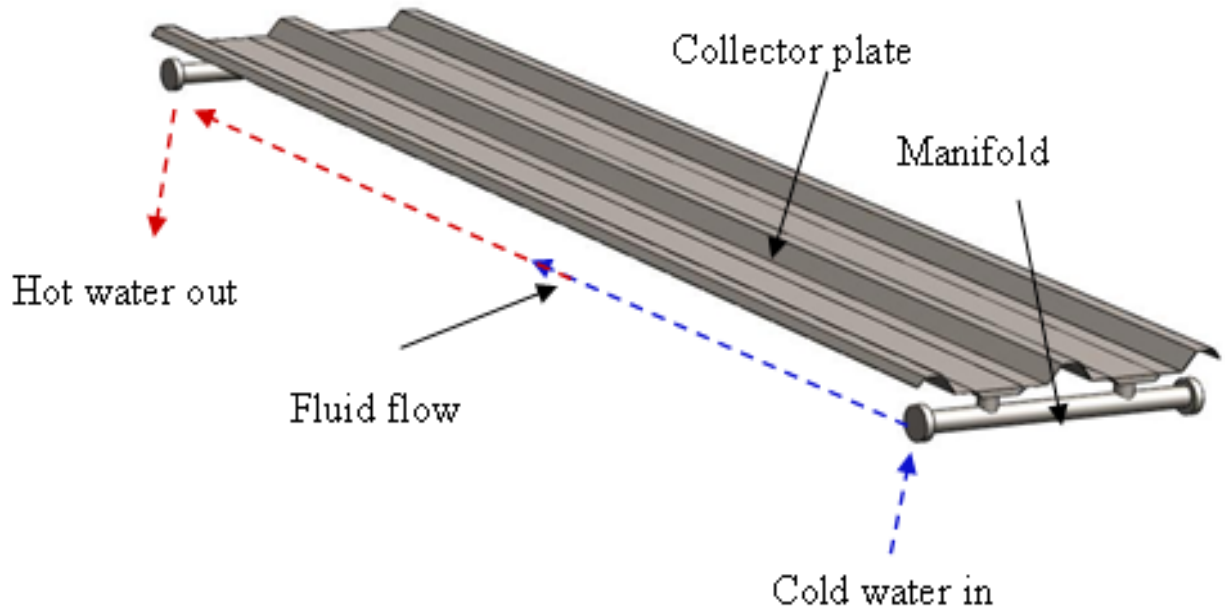
Solar Water Heating in NZ



Source: Electricity Commission 2010

- NZ residences use about one-third of total electricity consumption
- Water heating accounts for 26% of the household's electricity use
- To reduce electricity use, solar hot water system could be installed
- High growth in solar hot water system, around 35,000 home owners in New Zealand have now installed solar water heating systems and 3500 new systems installed each year in NZ (EECA2008: reported in January 2008)

Building Integrated Thermal (BIT) System @ University of Waikato (UoW)



Schematic of BIT Panel

- 2 meter lengths of black painted steel
- With 0.035m wide fluid channel

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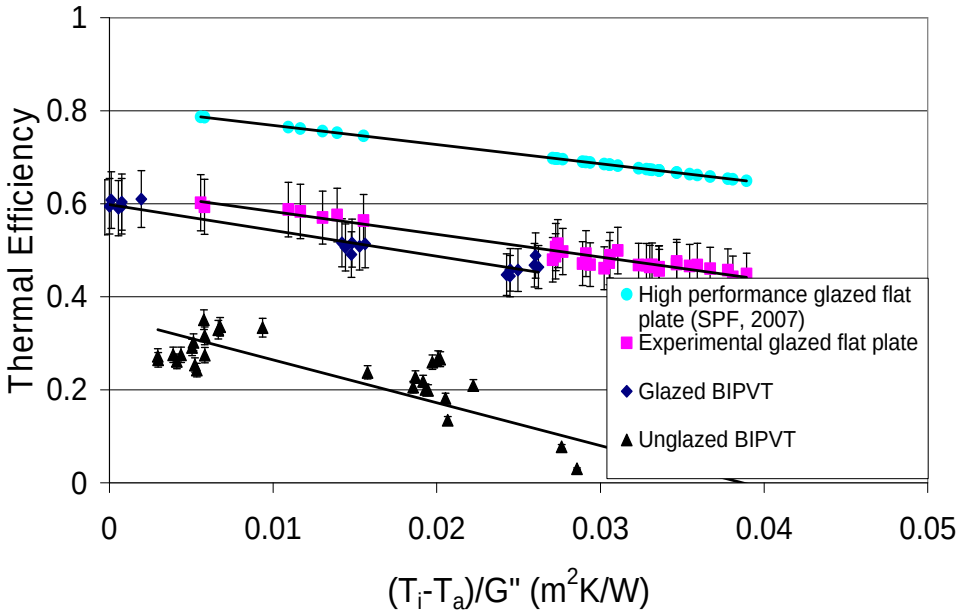
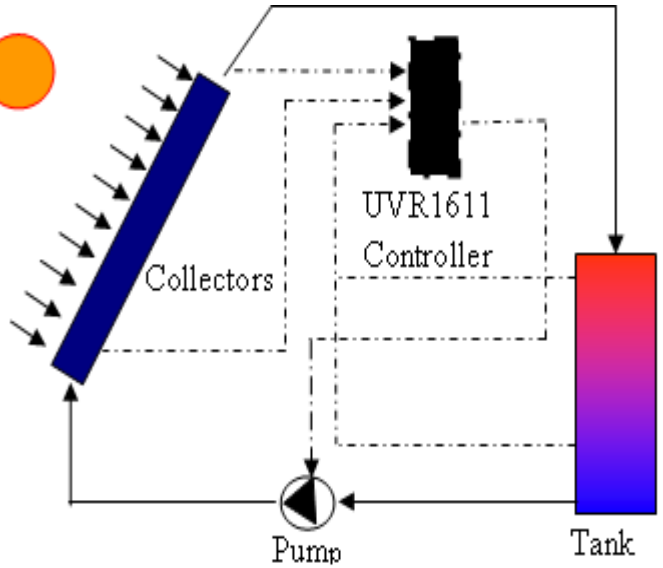


Theoretical and Experimental Performances of Optimised BIPVT Collectors (Anderson,2009)

Building Integrated Thermal (BIT) System @ University of Waikato (UoW)

Tube Width	0.035m
Tube Depth	0.005m
Collector Area	6.73m^2
Collector mounting angle	3.6^o
Insulated tank	135 liters

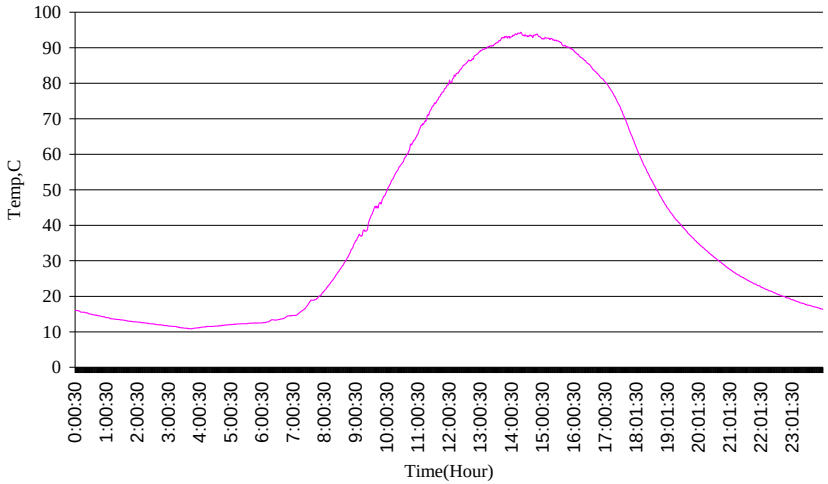
BIT Test Rig



Schematic diagram of the BIT system

BIT Experimental Testing

- Testing Performance



Water Temperature from Collector

- ~35 litres of water in tank at ambient temperature
- Clear sunny day, with an average solar insolation of 929 W/m^2
- Pump ON to circulate water through the glazed BIT
- The inlet and outlet temperatures were measured along with the flow rate and solar insolation

- Maximum temperature reached ~ 90^{o}C
- Well above required 50-60^{o}C of domestic hot water
- Demonstrates that glazed BIT can reach the required temperature

BIT Experimental Testing

The thermal efficiency can be determined directly from the experimental results based on the Hottel-Whillier equation (Duffie and Beckman, 2006).

$$\dot{Q} = \dot{m} C_p \Delta T$$

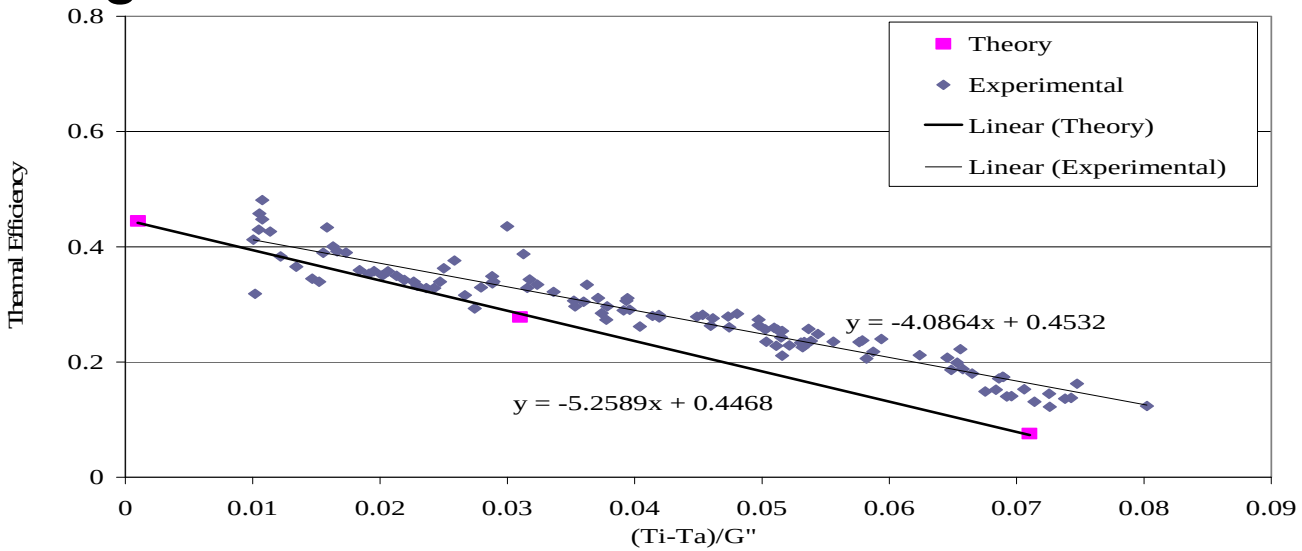
$$\eta = \frac{\dot{Q}}{A_{collector} G''}$$

From the experimental data, the efficiency of a solar collector for all conditions can be represented by a linear equation :

$$\eta = \eta_{0A} - a_1 \left(\frac{T_i - T_a}{G''} \right) \quad \Rightarrow \quad \eta = 0.4532 - 4.0864 \frac{T_i - T_a}{G''}$$

BIT Experimental Testing

- Testing Performance



Theoretical and Experimental Performance of BIT

- Glazed BIT was not optimised
- Glazed BIT still performed well enough to be an effective solar hot water system in 'sunny' regions

Conclusions

- The BIT solar collectors performed well and reached the required temperature for domestic hot water systems.
- The thermal performance of a solar roofing system was evaluated numerically and experimentally.
- The experimental efficiency is in good agreement with theoretical result.
- It is possible to integrate an effective solar hot water system directly into standard roof material.

Further Work

- To identify and design control strategies for the BIT system and determine how the performance can be optimized.

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Thank You