Development of a Building Integrated Photovoltaic/Thermal Solar Energy Cogeneration System

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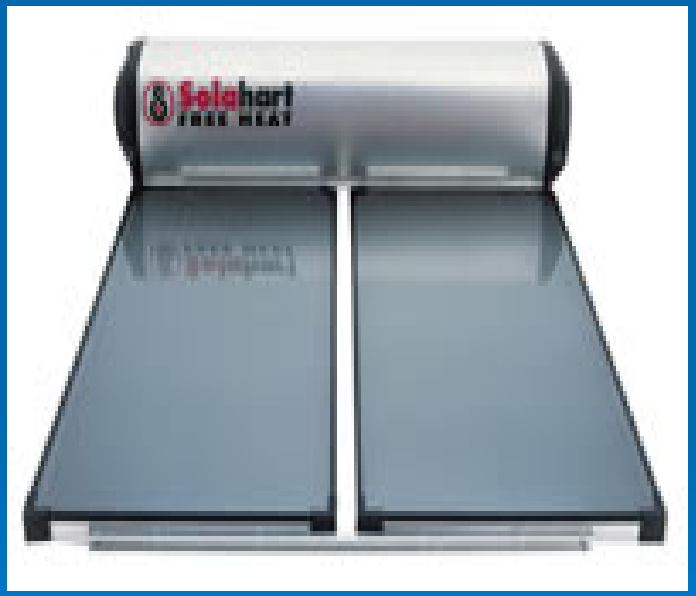
Solar Energy and NZ

- New Zealand land mass conservatively collects 1.4×10^{21} J per year
- An average house rooftop of $150 m^2$ collects 2.2×10^{8} Wh per year ie. 20 to 30 times the house's total requirements.
- Hamilton receives ~5000 MJ/m^2/year

Existing Solar Technologies

- Solar Thermal



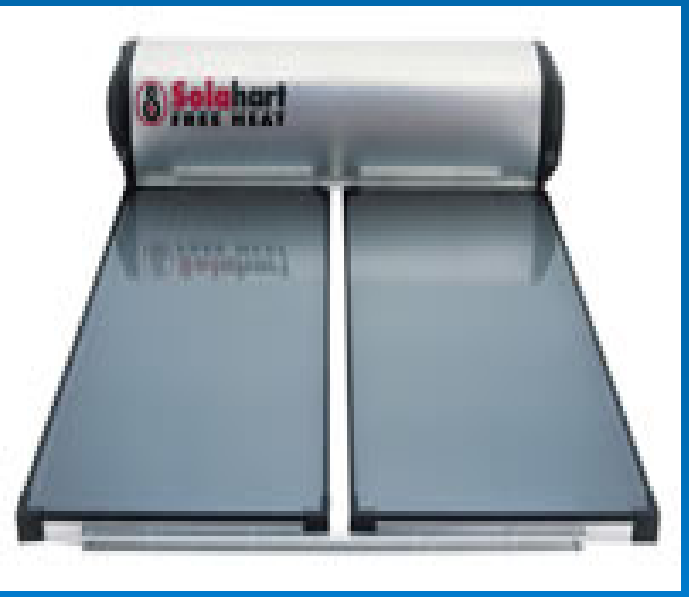
Source: www.solahart.com.au

- Photovoltaics

Source: www.bpsolar.com

What is a Photovoltaic/Thermal Solar Collector

Solar Thermal + Photovoltaics = PVT



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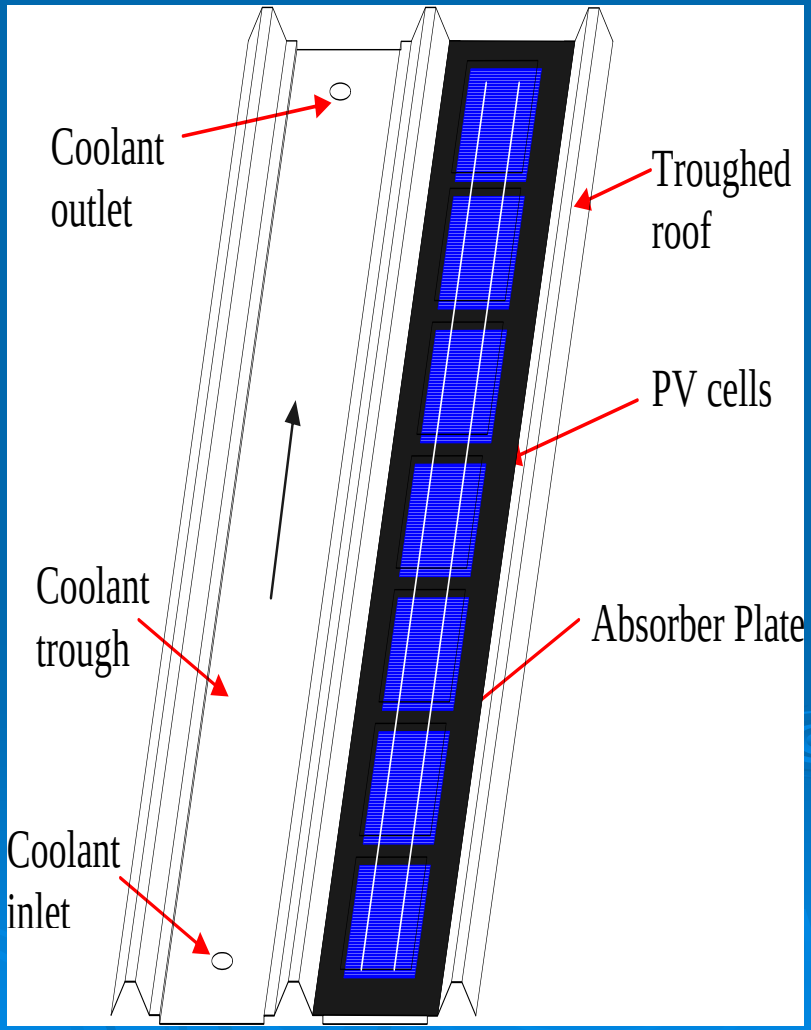
PV T Collectors

- Photovoltaic and solar thermal in a single device: Cogeneration of heat and power
- PV-cell efficiency decreases with increasing temperature
- Efficiency of PV cells increased by active cooling
- Area dedicated to solar energy devices can be reduced

BIPVT Concept

- Integrates PV cells with sheet metal roofing
- Passageways for cooling medium
- Glass or polymer glazing



Designing BIPVT for Production

- Corrugating a flat metal sheet
- Punching holes for thermal fluid inlets and outlets.
- Bonding the collector plate to the troughed roof
- Sealing the central channels
- Mounting fittings to connect manifolds
- Laminating PV cells onto the collector plate
- Sealing the edges between collector plate and troughed roof
- Connecting manifolds to the inlet and outlet

Capital Costs for Production Systems

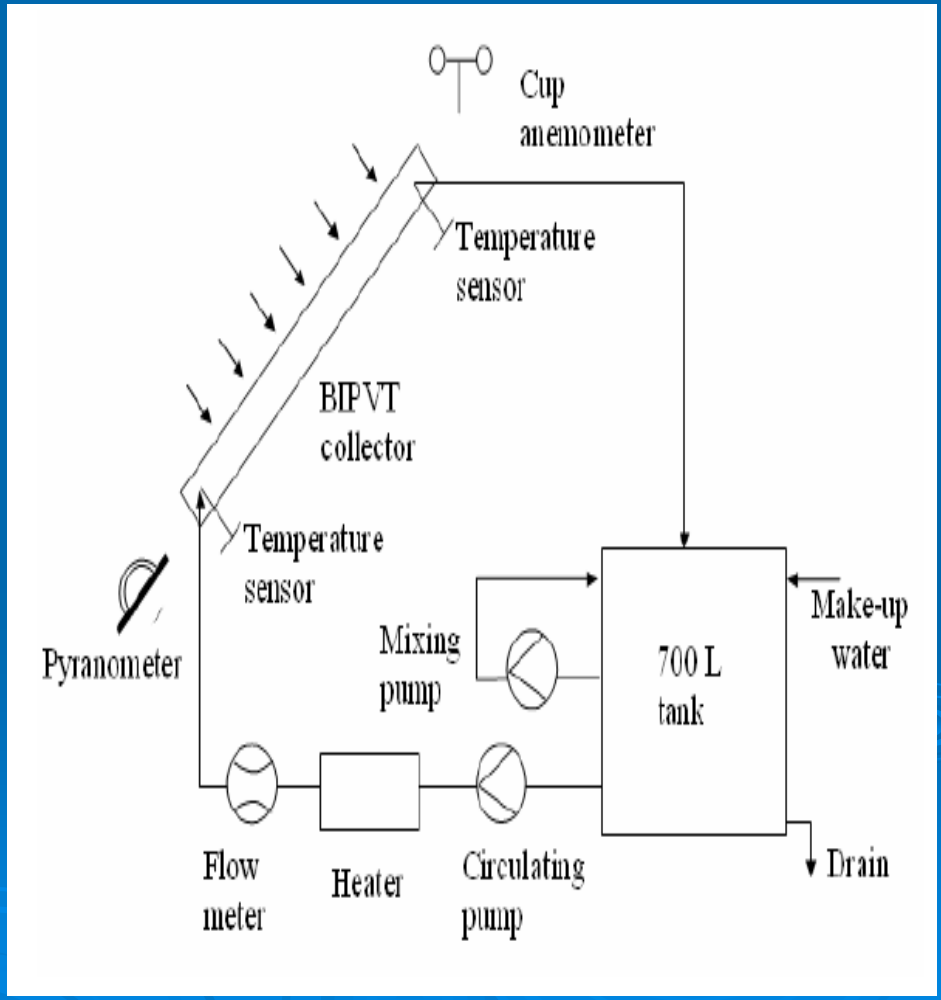
Operation no.	Production step	Equipment cost		
		Adhesives	Seam Welding	Autoclave
1	Corrugation of plain sheet	$250,000	$250,000	$250,000
2	Punching holes on corrugated sheet	$10,000	$10,000	$10,000
3	Joining collector plate with corrugated sheet	$33,500	$80,000	$600,000
4	Sealing ends on central channel		$5,000	
5	Mount fittings on corrugated sheet	$5,000	$5,000	
6	Laminating PV strings on collector plate	$400,000	$400,000	
7	Sealing the bonded edges between collector plate and corrugated sheet	$5,000	$5,000	$5,000
8	Attaching manifolds to the corrugated sheet	$5,000	$5,000	$5,000
Total equipment cost (TEC)		**$708,500**	**$760,000**	**$870,000**
Capital investment (CI = TEC x Lang factor 3.06)		**$2,168,010**	**$2,325,600**	**$2,662,200**

Payback Period for Production Systems

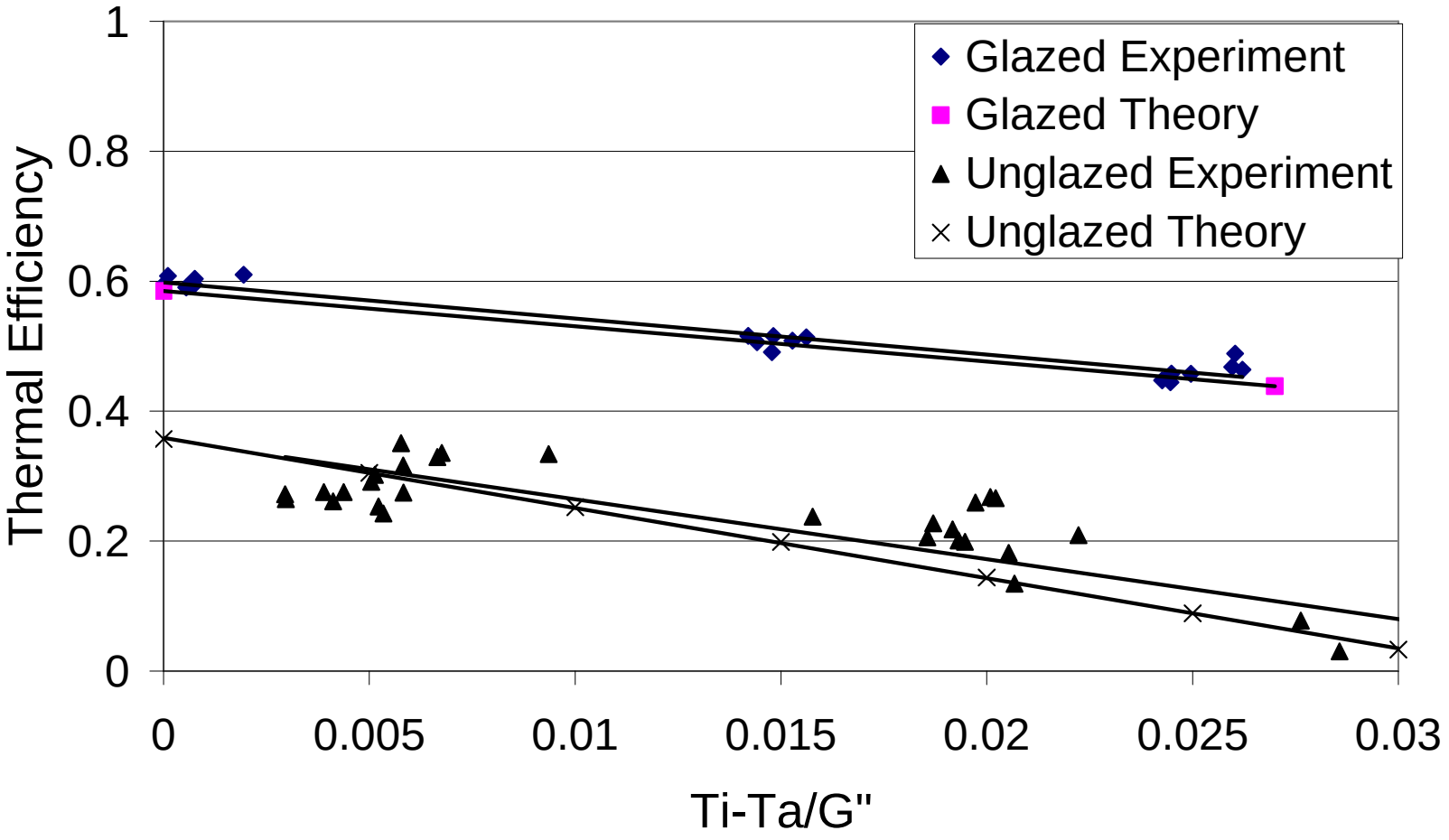
Production step	Production system		
	Adhesives	Seam Weld	Autoclave
Capital investment (CI)	$2,168,010	$2,325,600	$2,662,200
Deprecation (DC = 20% of CI)	$433,602	$465,120	$532,440
Panels per year for 1,920 hrs operating time (N)	7,680	6,400	17,280
Total operating costs per year (TO)	$8,359,535	$7,048,000	$18,640,200
Cost per panel (CP = TO/N)	$1,088	$1,101	$1,079
Market value per panel (MV)	$1,400	$1,400	$1,400
Revenue before tax (RT = MV x N)	$10,752,000	$8,960,000	$24,192,000
Gross profit before tax (GP = RT – TO)	$2,392,465	$1,912,000	$5,551,800
Gross profit after tax (33%) (GPT = GP x 0.67)	$1,602,952	$1,281,040	$3,719,706
Net profit per year (NP = GPT + DC)	$2,036,554	$1,746,160	$4,252,146
Gross margin (GM = GPT/RT)	14.91%	14.30%	15%
Return on investment (ROI = NP/CI)	94%	75%	160%
Payback time (years) (PT = CI/NP)	**1.06**	**1.33**	**0.63**

BIPVT Testing and Analysis

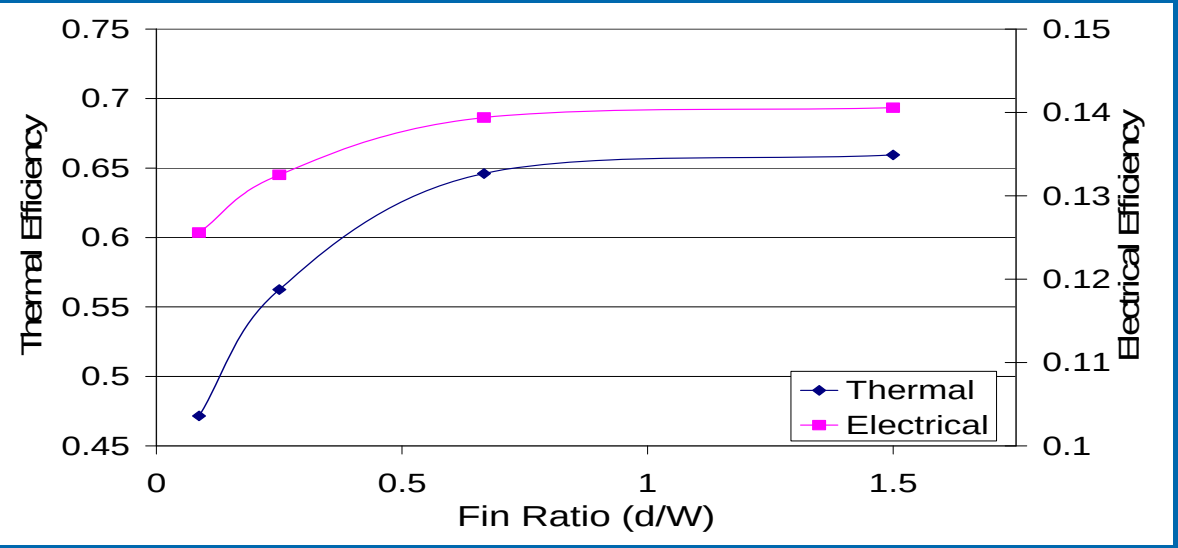
- Steady state outdoor thermal test per AS/NZS 2535.1
- One dimensional steady state thermal model

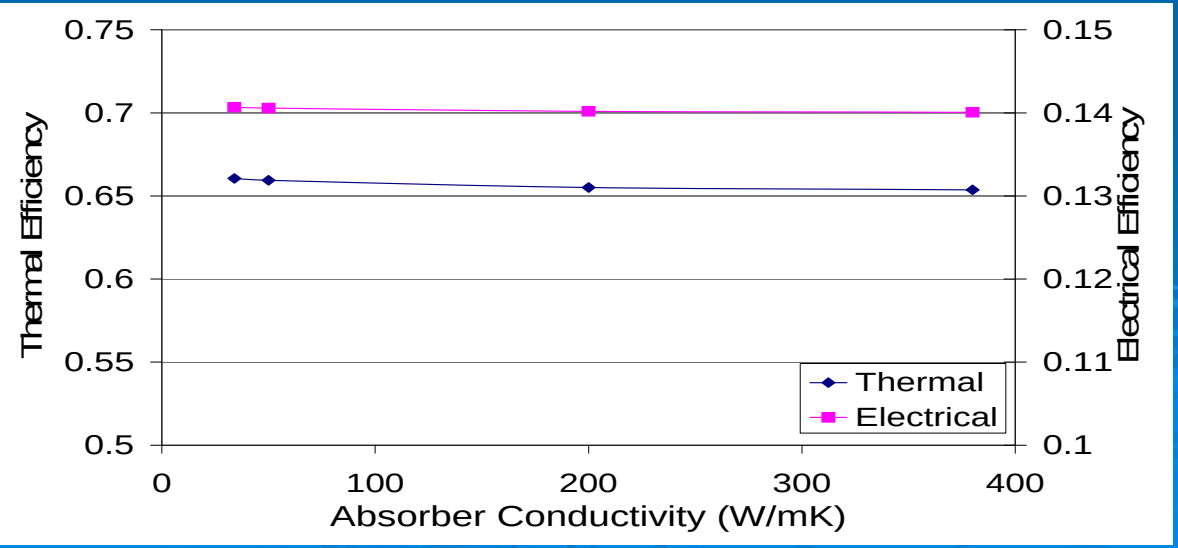


Results for BIPVT Testing and Modelling



Improving BIPVT Performance

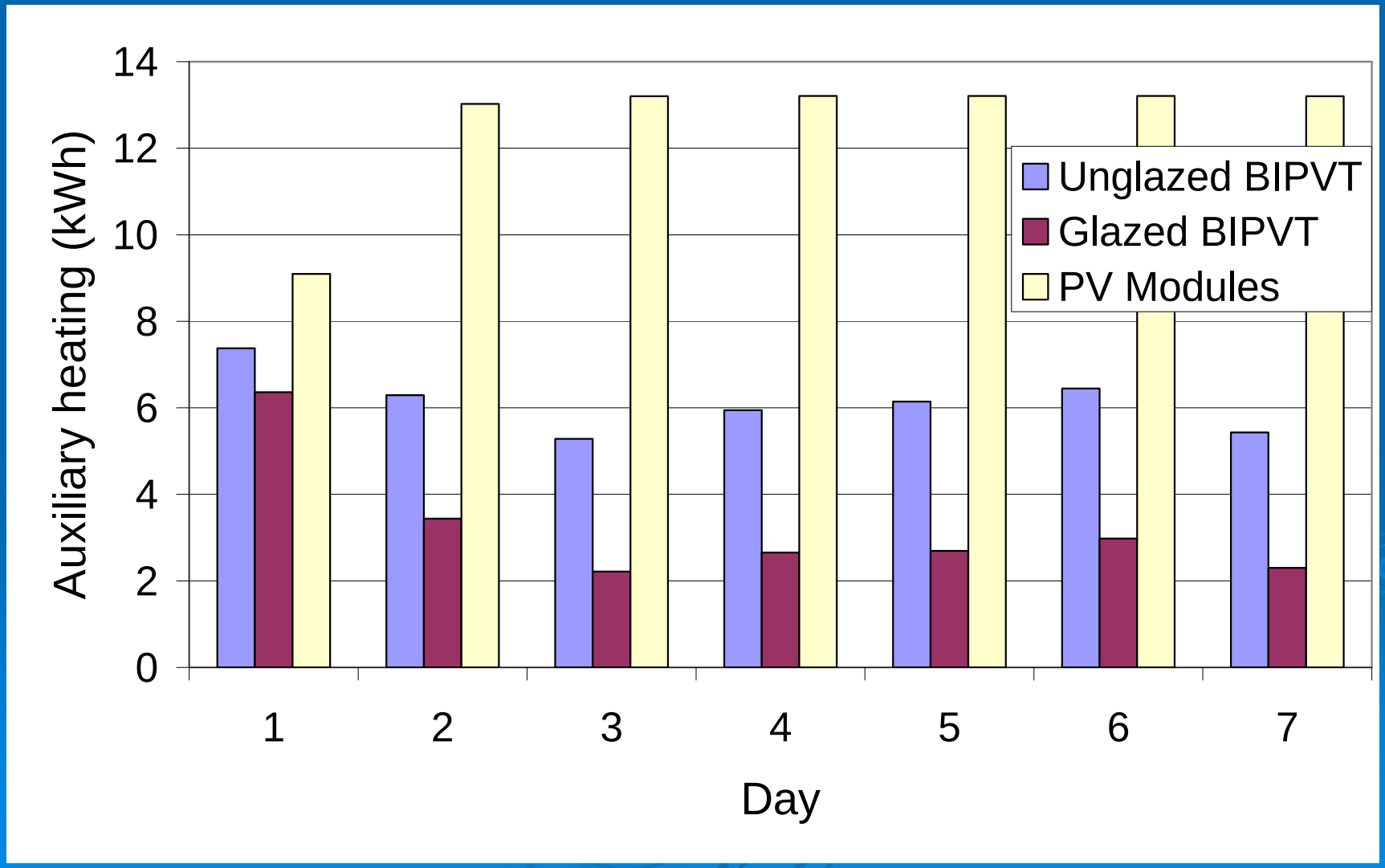




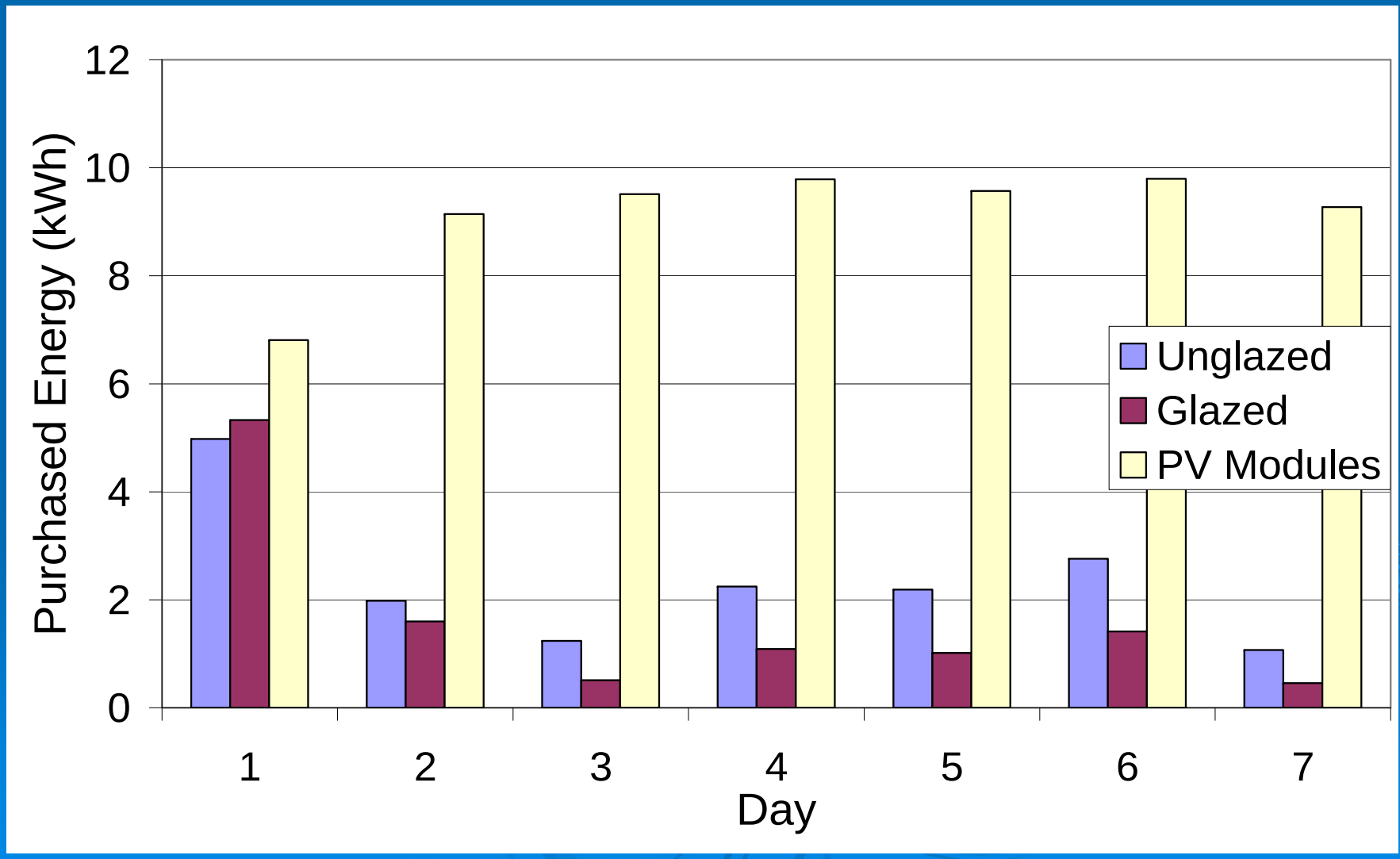
Long Term Performance of BIPVT

- Simulation performed using TRNSYS
- $4m^2$ BIPVT system, with a packing factor of 50%, coupled to a 300 L
- Water use profile specified in AS 4234:1994 for a typical meteorological year in Auckland

Auxiliary water heating demand for different collectors



Net energy purchased to meet water heating load



Conclusions

- Possibility of using low cost materials such as steel
- Reduce the need for multiple solar installations while also achieving an architecturally sensitive appearance
- Suited to high density living