

Investigation of Production Systems for a Building Integrated Photovoltaic-Thermal Product

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BIPVT

- **Integrates photovoltaics and solar thermal panels into building products**
 - **Walls, windows and roofing**
 - **Generate electricity and heat**
- **Currently either BIPV or BIT commercially available**
- **BIPVT being investigated and developed by University of Waikato**



SunTechnics



Solar Integrated



Dronningegården folkcentre



DOE/NREL



Sunslate Atlantic Energy systems



Georgetown Uni. Washington

BIPV Products

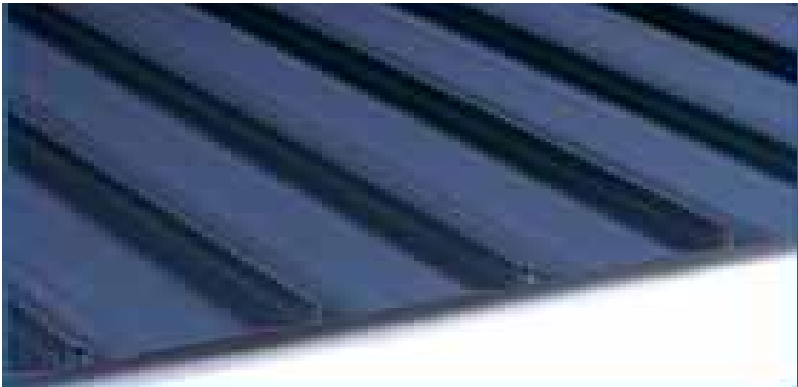
Overview of Research

- Integrate PV and ST into long run roofing
 - Done in conjunction with Dimond Ltd., NZ roofing supplier
 - Funded by the Building Research Group
- Investigate different manufacturing methods
- Manufacture prototypes
- Economic analysis

Long-run Roofing Products



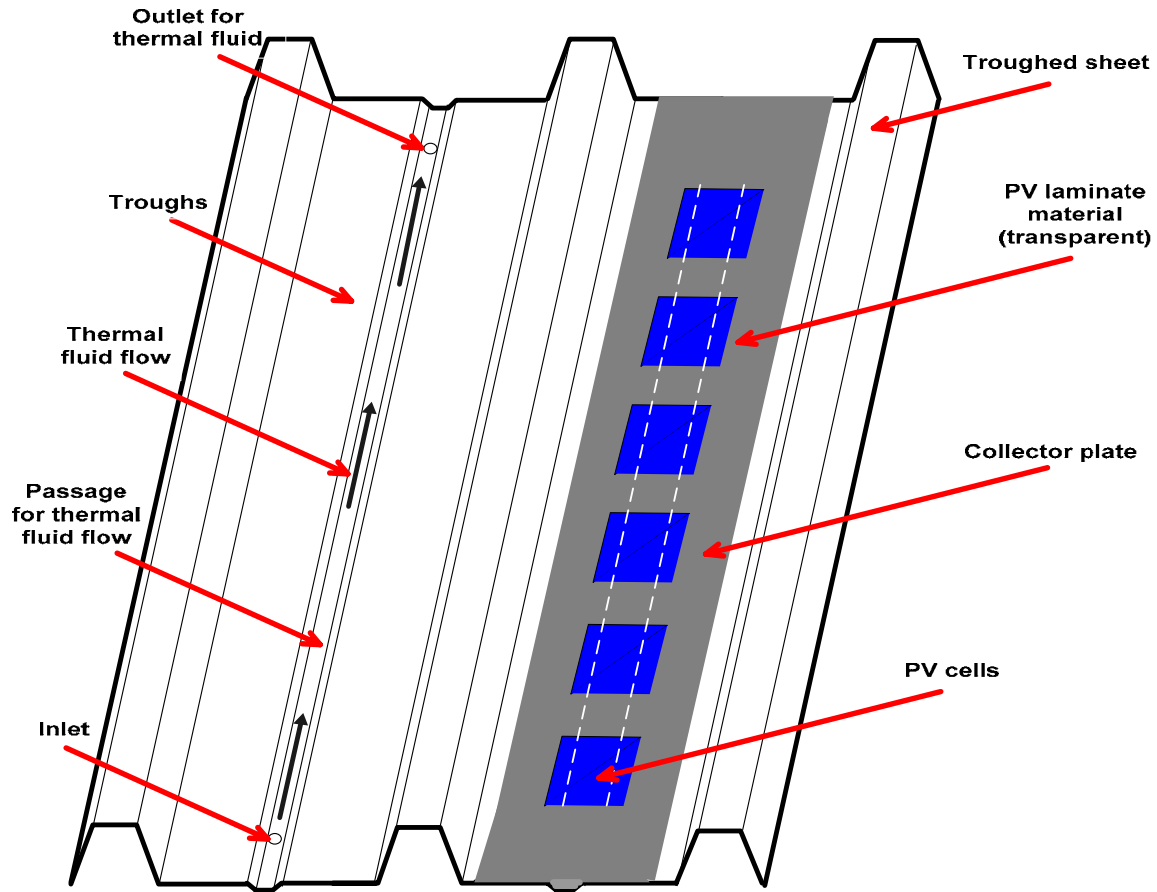
■ Profile Metric (from Dimond)



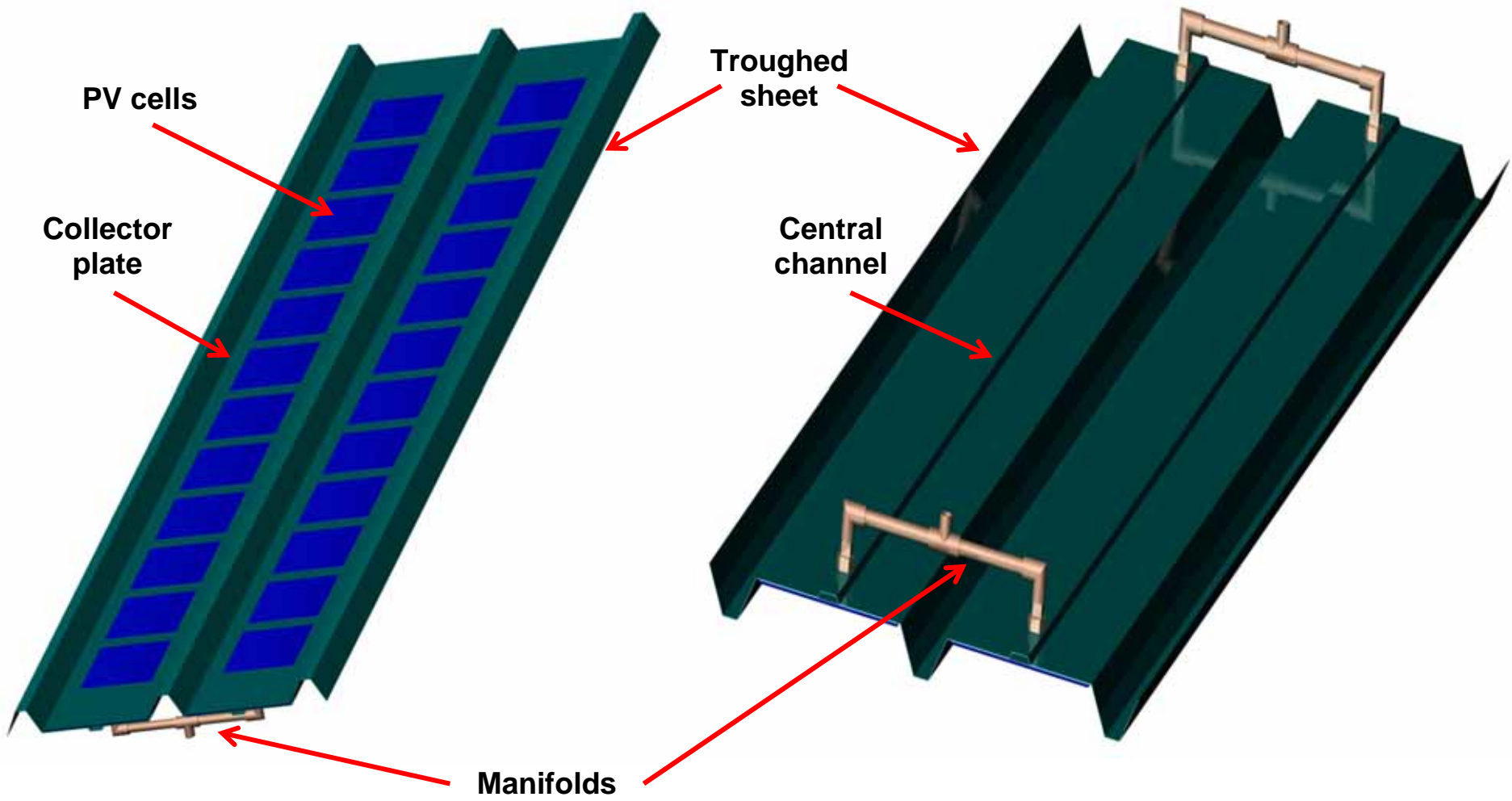
■ Profile Dimondek 400 (from Dimond)

- Aluminium
- Galvsteel
- Colorcote

BIPVT Product



BIPVT Product



Basic Production Methodology

■ Production steps:

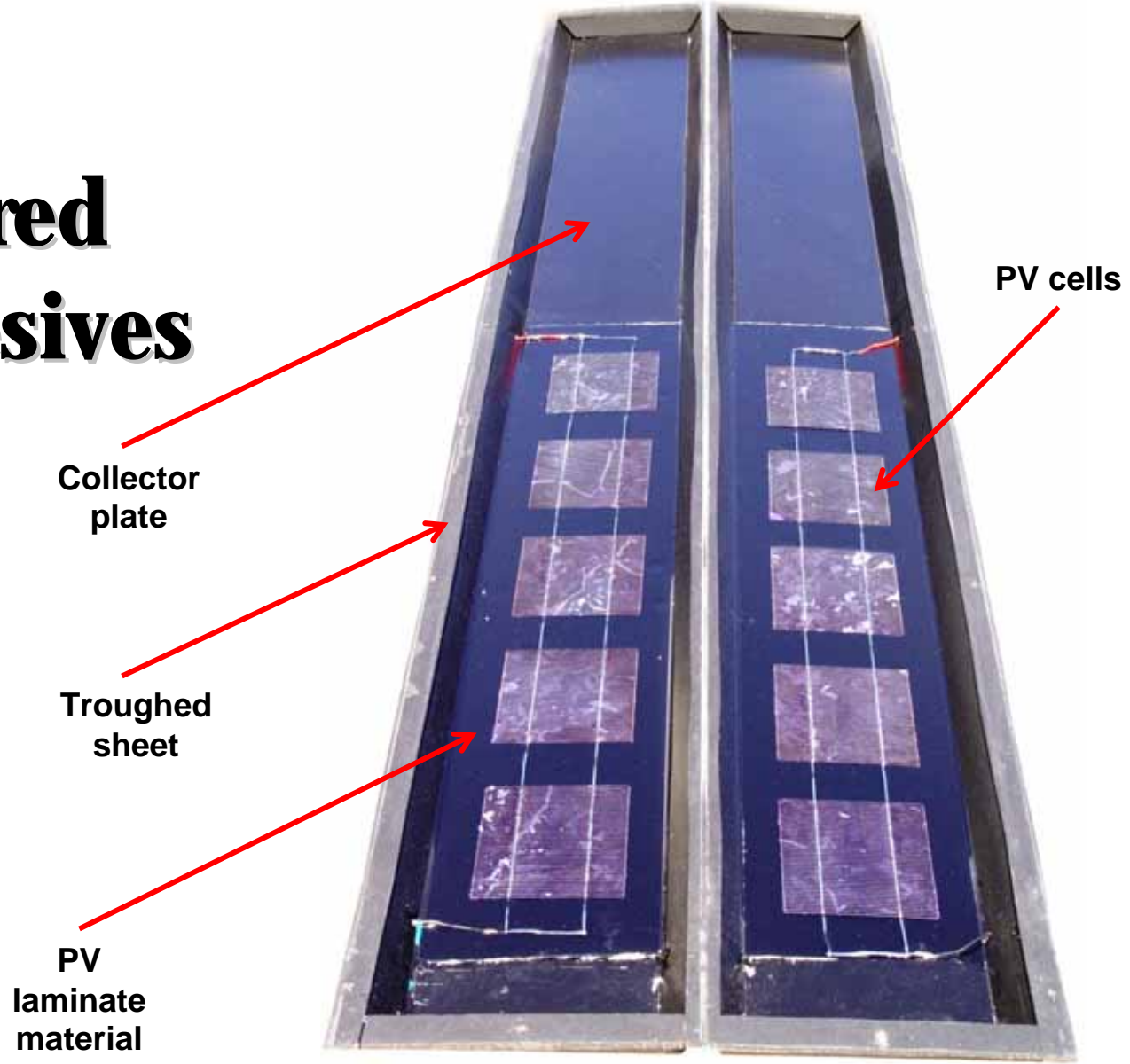
- Shape (trough) flat metal sheet
 - Press-brake
- Punch holes in central channels for manifold fittings
- Join collector plate to the troughed sheet (defining step)
 - adhesives + autoclave, resistance seam welding
- Seal central channel ends
 - adhesives, brazing
- Install manifold fittings in holes on central channels
 - adhesives, brazing
- Laminate PV cells on collector plate
 - Vacuum lamination, autoclave
- Seal edges around the collector plate
- Connect manifolds to fittings on central channels

Production Methodology

Oper. No.	Production step	ADH	RSW	ATC
1	Corrugation of plain sheet by press-brake	Press-brake		
2	Punching holes on corrugated sheet	Hole punch		
3	Joining collector plate with corrugated sheet	ADH	RSW	ATC
4	Sealing ends on central channel		Brazing	
5	Mount fittings on corrugated sheet	ADH	Brazing	
6	Laminating PV strings	Vacuum laminator		
7	Sealing the bonded edges between collector plate and corrugated sheet	Using sealant		
8	Attaching manifolds to the corrugated sheet	Mechanical fastening		

ADH- Adhesive, RSW – Resistance seam welding, ATC - Autoclaving

BIPVT Prototype Manufactured using Adhesives



Capital Costs

Oper. no.	Production step	Equipment cost		
		ADH	RSW	ATC
1	Corrugation of plain sheet by press-brake	\$250,000	\$250,000	\$250,000
2	Punching holes on troughed sheet	\$10,000	\$10,000	\$10,000
3	Joining collector plate with troughed sheet	\$33,500	\$80,000	\$600,000
4	Sealing ends on central channel		\$5,000	
5	Mount fittings on troughed 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 troughed sheet	\$5,000	\$5,000	
8	Attaching manifolds to the troughed 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

Process Times

Oper. no.	Production step	Time per panel (minutes)		
		ADH	RSW	ATC
1	Corrugation of plain sheet by press-brake	2	2	2
2	Producing holes on troughed sheet by punching	2.5	2.5	2.5
3	Joining collector plate to troughed sheet	10	18	20
4	Sealing central channels at each end		5	
5	Mounting fittings to the troughed sheet	5	5	
6	Lamination of PV strings on collector plate	15	15	
7	Sealing the edges between bonded troughed sheet and collector plate	4	4	4
8	Attaching manifolds to troughed sheet	4	4	4
Total labour per panel (min)		42.5	55.5	32.5
Rest time in cycle between steps (min)		5	7	5
Total panel processing time (min)		47.5	62.5	37.5
Process throughput (panels/min) based on slowest step		0.07	0.06	0.15
Panels per year for 1,920 hrs operating time		7,680	6,400	17,280

Material Costs

Component	Qty.	Cost per panel(\$)
Troughed sheet	3.384 m ²	\$228
Collector plate	2.16 m ²	\$146
PV laminates (total)	1.49 m ²	\$600
Nuts and hollow stud bolts	4	\$40
Copper tubes for manifolds	0.6 m	\$30
Consumables		\$6
Total cost per panel		\$1,050

Cost per Panel

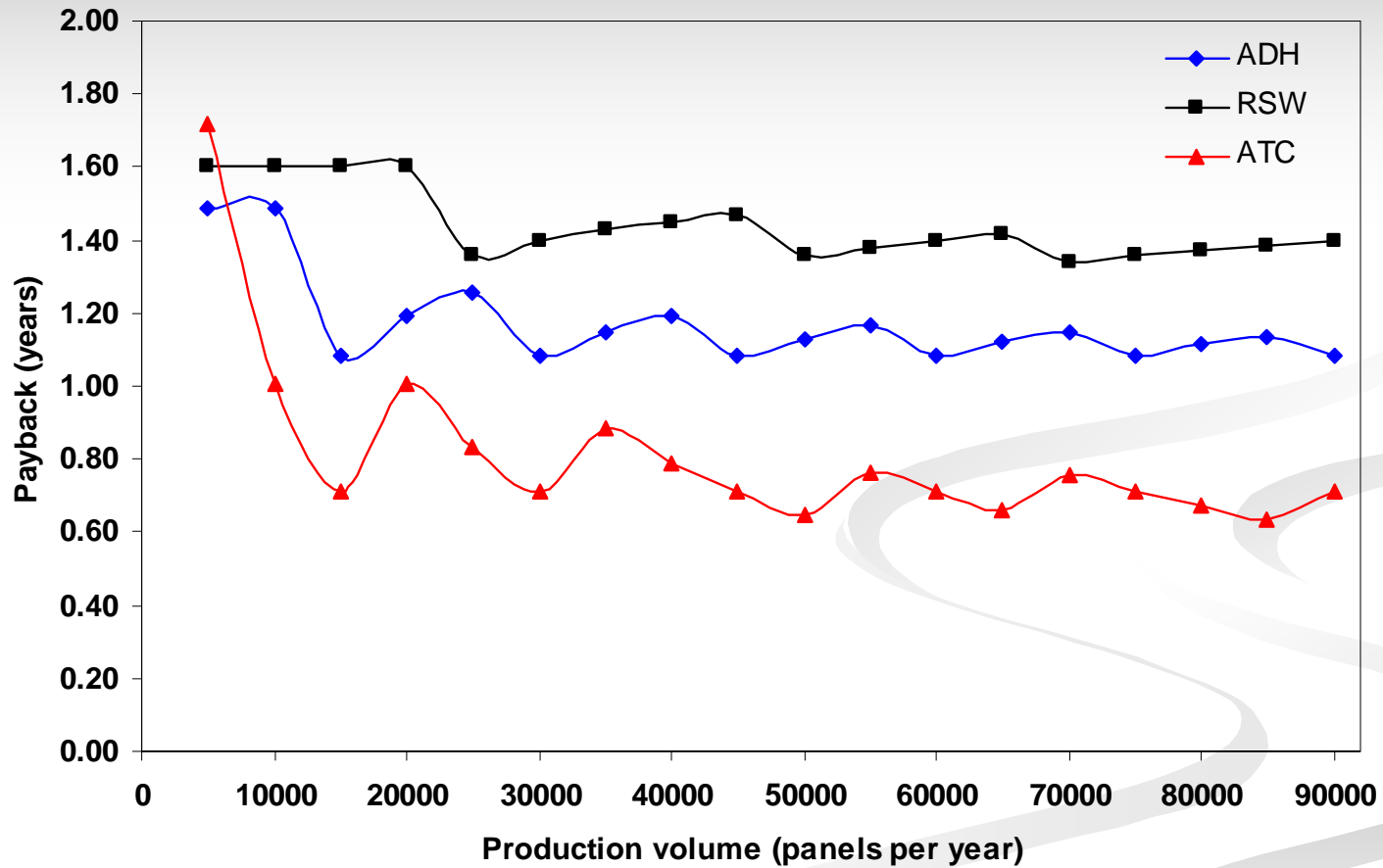
Labour, Machine and Energy

Parameter	Production system		
	ADH	RSW	ATC
Total equipment cost (TEC)	\$708,500	\$760,000	\$870,000
Panels per year for 1,920 hrs operating time (N)	7,680	6,400	17,280
Labour per panel (min)	42.5	55.5	32.5
Labour cost per panel (including overhead) (LC)	\$28	\$37	\$22
Labour cost per year (A=LC x N)	\$217,600	\$236,800	\$374,400
Machine operating cost per year (B = 10% of TEC)	\$70,850	\$76,000	\$87,000
Equipment energy consumption per year (C=1% of TEC x factor)	\$7,085	\$15,200	\$34,800
Material cost per panel Colorcote (Unglazed) (MP)	\$1,050	\$1,050	\$1,050
Material cost per year (D=MP x N))	\$8,064,000	\$6,720,000	\$18,144,000
Total operating costs per year (TO = A+B+C+D)	\$8,359,535	\$7,048,000	\$18,640,200
Cost per panel (CP = TO/N)	\$1,088	\$1,101	\$1,079

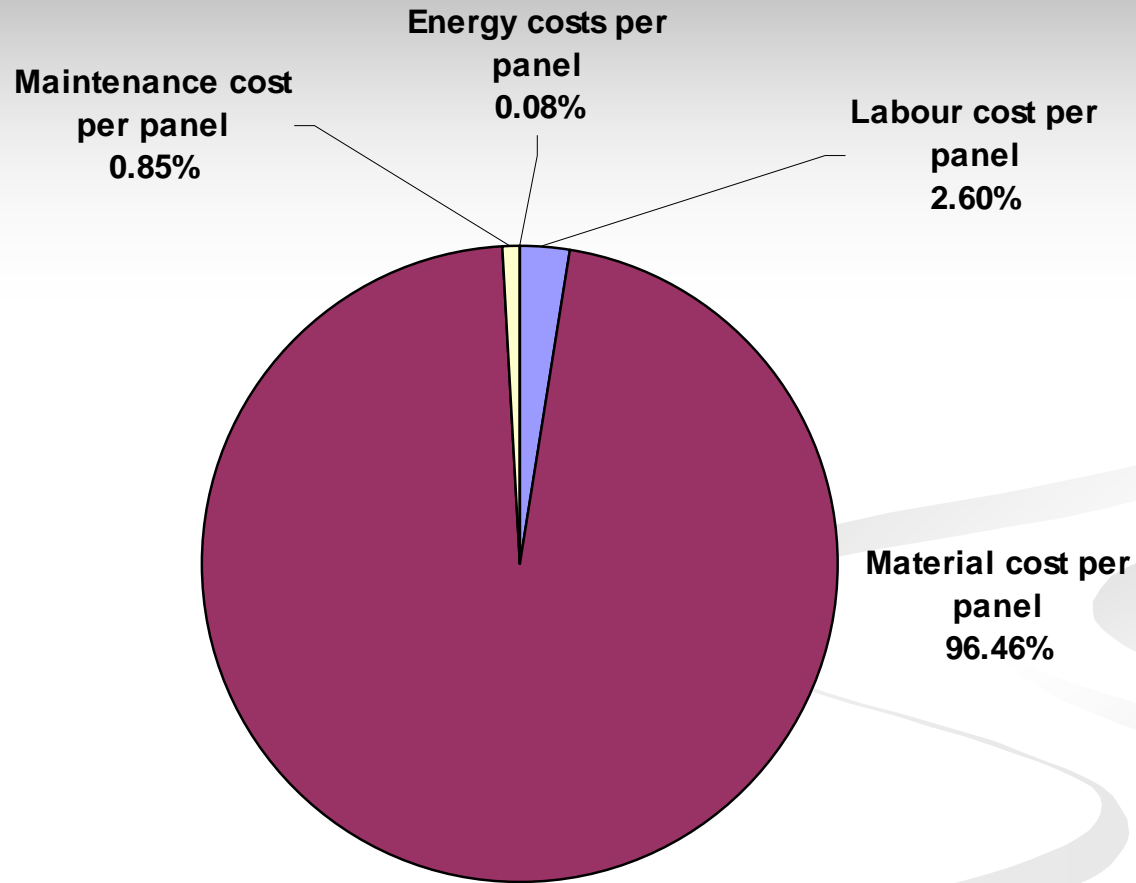
Payback Period and Net Profit Analysis

Item/Category	Production system		
	ADH	RSW	ATC
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

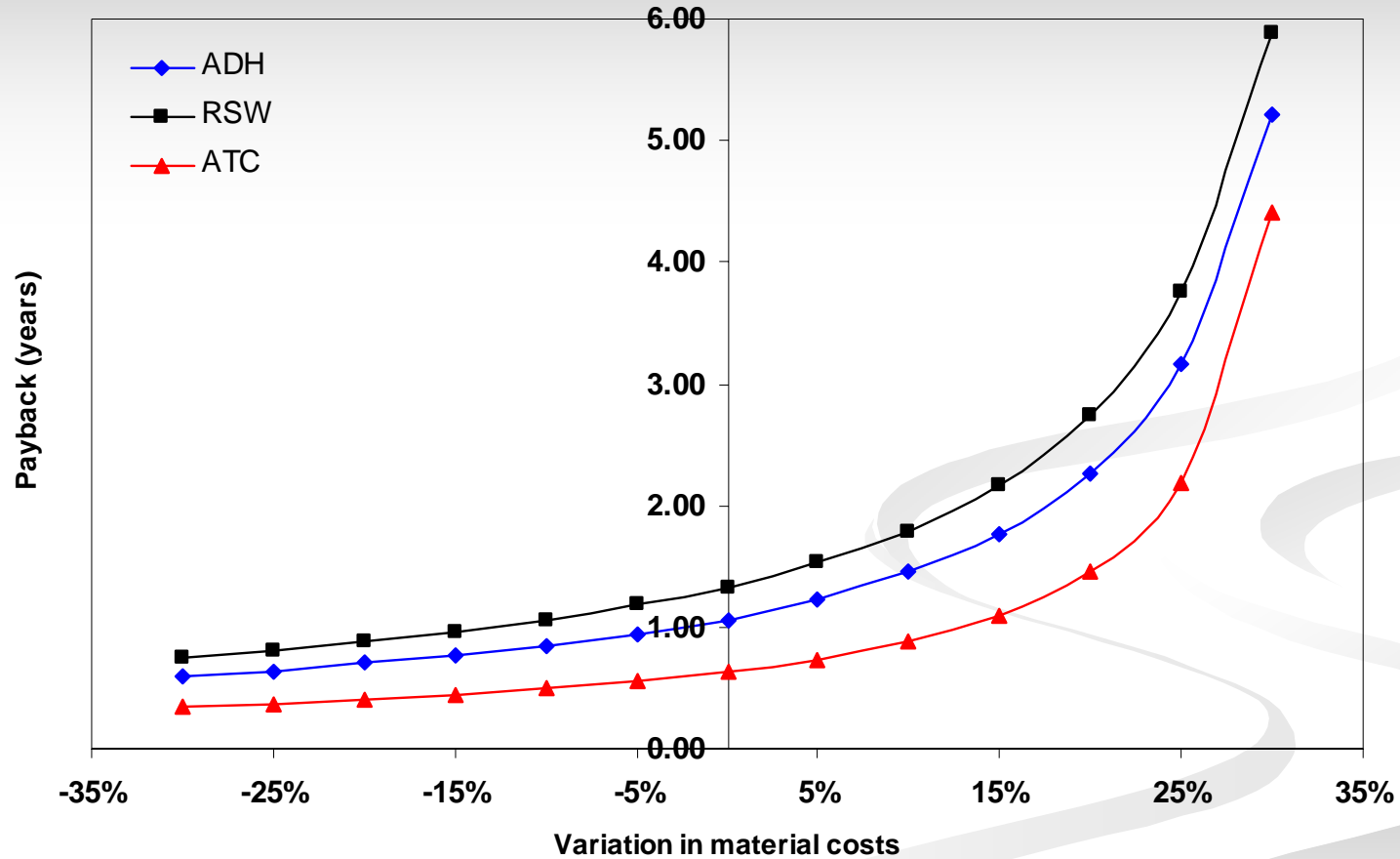
Payback Time vs Production Volume



Material Costs



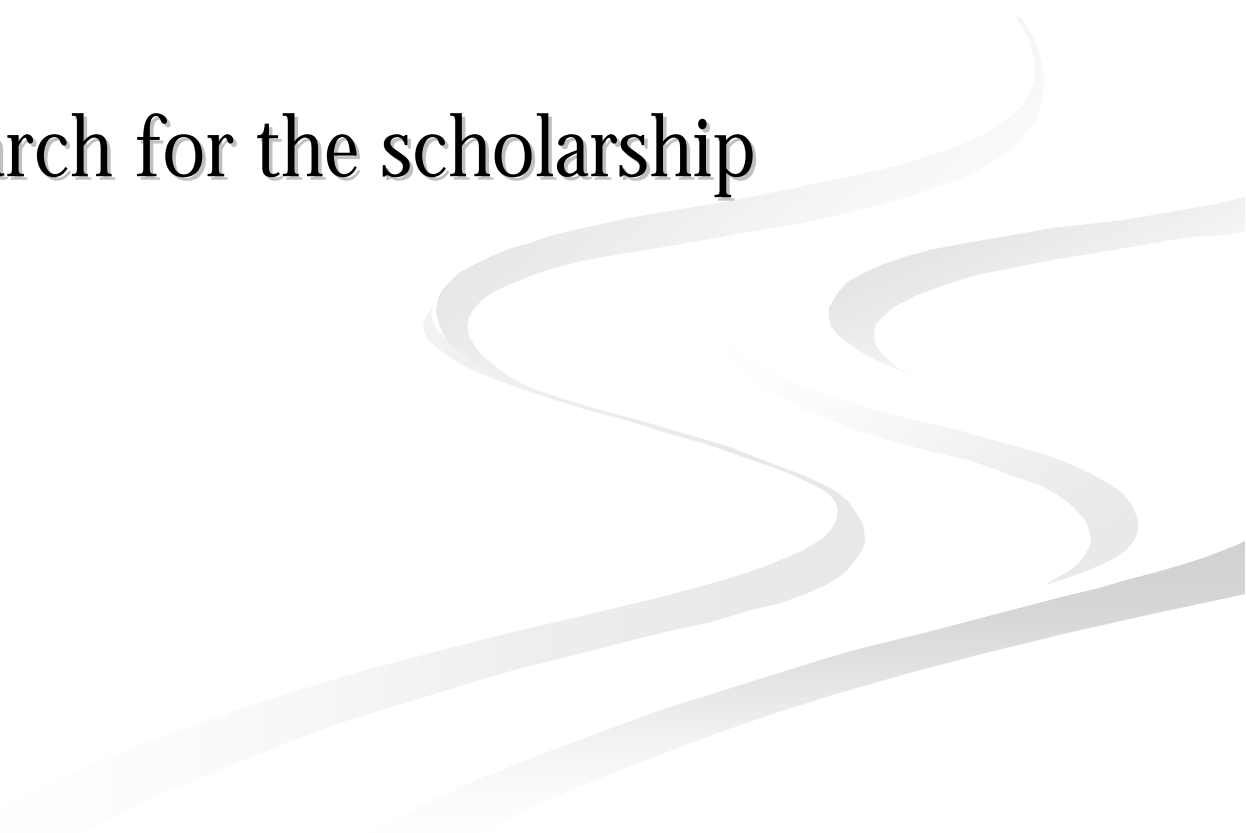
Material Cost and Payback Time



Conclusions

- Adhesives (ADH), resistance seam welding (RSW) and autoclaving (ATC) were considered the most suitable for manufacturing BIPVT
- After economic analysis, $ATC > \text{approximately } 6,000$ and $ADH < 6,000$ BIPVT panels per year
- Material costs account 95% of the total operating costs.
- Payback time reduces with production volume
- ATC needs to be investigated for overcoming several challenges

Acknowledgements

- Dimond Ltd. for supplying trough sheets and collector plates, and assisting with process costing
 - Building Research for the scholarship
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- The bottom right portion of the slide features several thick, light gray wavy lines that curve and flow across the page, serving as a decorative background element.