



EVCUATED GLASS TUBE SOLAR AIR HEATER

Low Cost Light Weight Design for Medium Temperature Applications

*Developed at
Heat Pump Laboratory*

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OUTLINE OF PRESENTATION

- ***Introduction***
 - ✓ Need and scope for medium temperature Solar Air Heaters
 - ✓ Objectives and methodology
- ***Literature Review***
 - ✓ Present status of solar heating technologies
- ***Development of Evacuated Glass Tube Solar Air Heater Based on***
 - ✓ Concentrating Collector Technology with Parabolic Reflector
 - *Design and fabrication*
 - *Experimentation, analysis and result presentation*
- ***Evaluate Techno-Economical Viability for***
 - ✓ Non / seasonal-tracking Solar Air Heater with east-west orientation
- ***Conclusion and Future Recommendation***



INTRODUCTION

Need, Objectives and Methodology

- ***Need for Solar Collector***

- ✓ Various concerns with use of conventional energy sources
 - *Resources depleting fast, De-forestation, global warming*
 - *Environmental pollution, land de-gradation and health hazards*
 - *Rapidly rising of fuel prices*
- ✓ Benefits of Solar heating
 - *Free of cost, clean and inexhaustible*
 - *Everywhere and abundantly available*
 - *Free from political hindrance*

- ***Objectives of the Present Work***

- ✓ Feasibility study for development of
 - *Evacuated Glass Tube Solar Air Heater with Parabolic Reflector*
- ✓ Identify, design, fabricate and integrate the components of
 - *Evacuated Glass Tube Solar Air Heater with Parabolic Reflector*
 - *Investigate the techno-economical viability of Air Heater*

- ***Methodology***

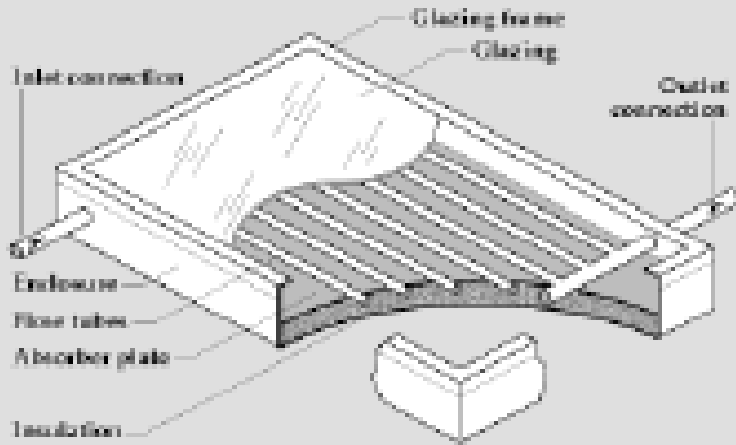
- ✓ Literature review: various collector technologies
- ✓ System simulation, drawing and fabrication
- ✓ Experimentation and performance analysis taking air as heat transfer fluid



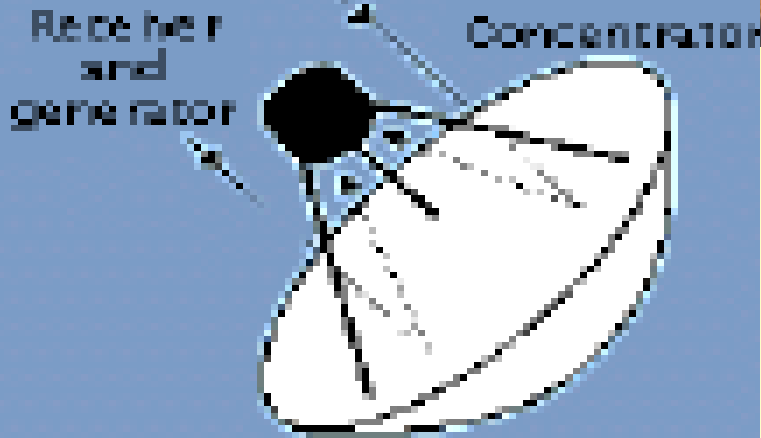
SOLAR AIR HEATER

Various Types (www.nrel.gov)

Flat-Plate Collector



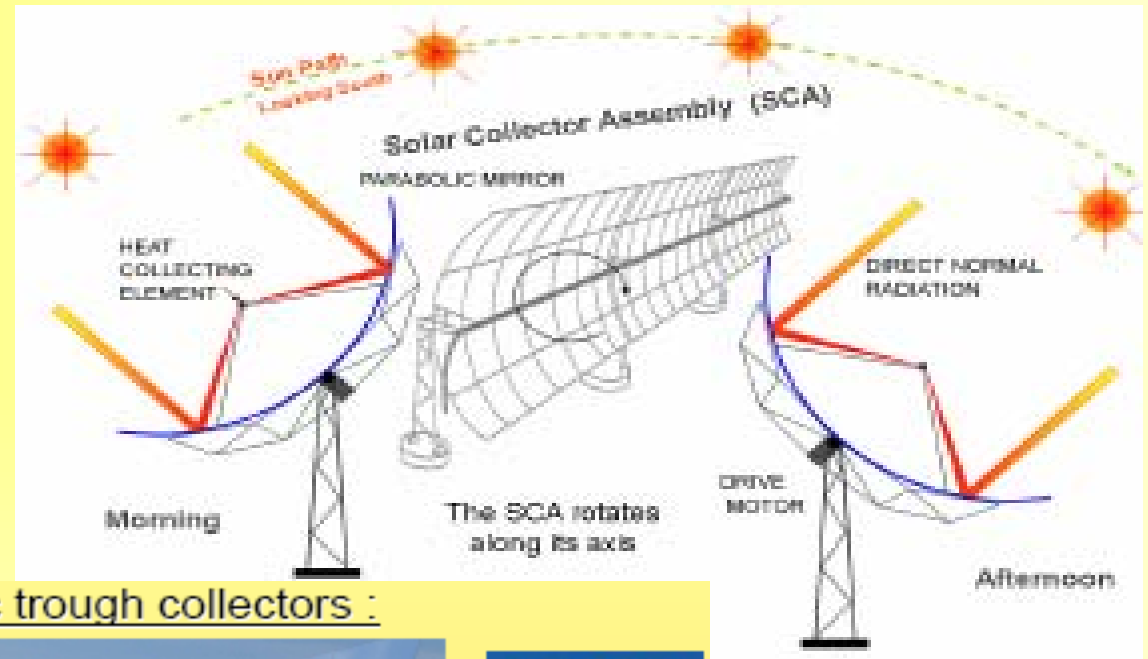
Solar Dish/Engine





PARABOLIC TROUGH TECHNOLOGY

Literature Review



High Temperature Parabolic trough collectors :



Mirror & Mirror Structure Collector Field Design

SKAL-ET collector loop in SEGS V / Kramer Junction



Absorber Tube

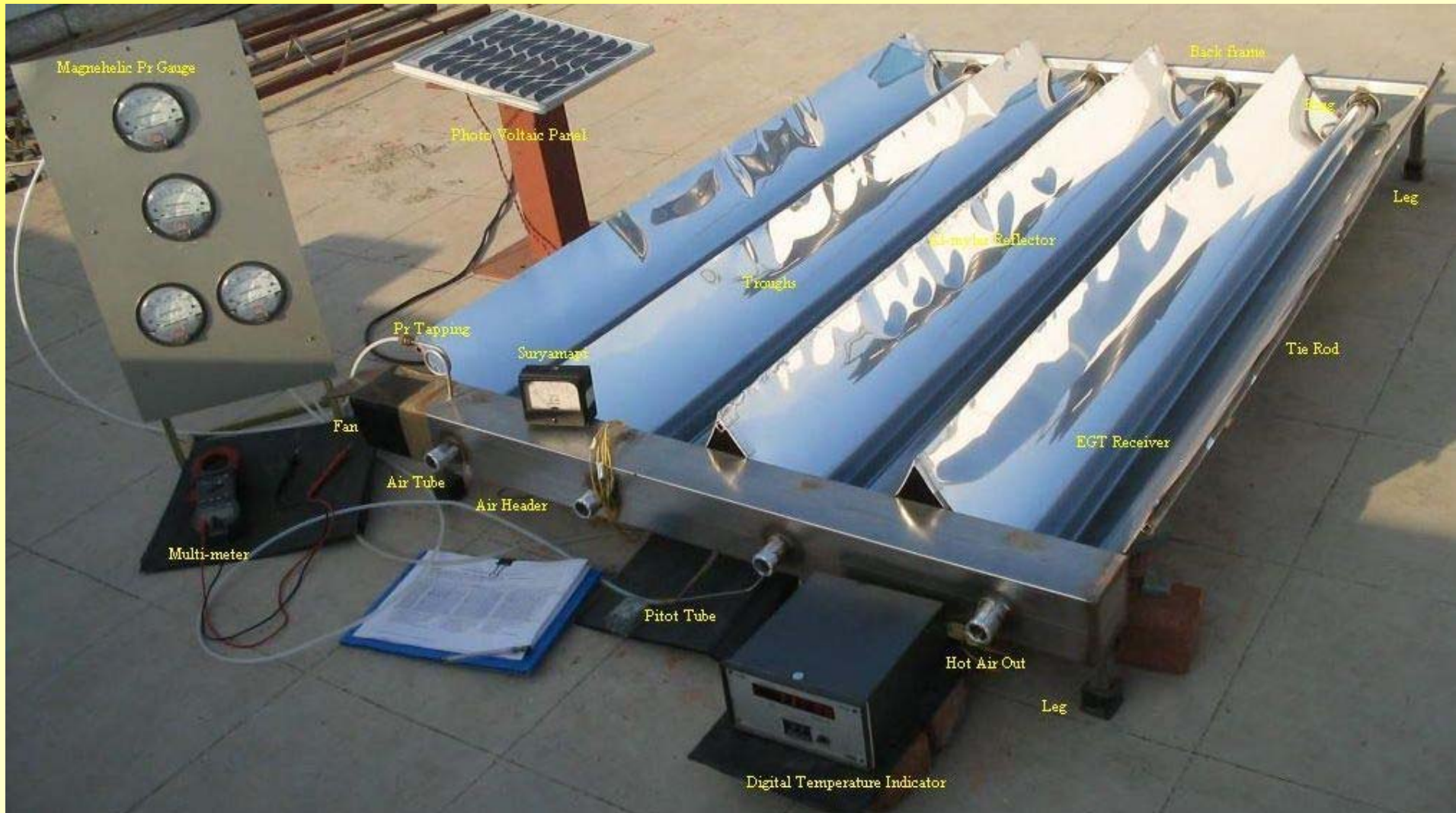
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EVACUATED GLASS TUBE SOLAR AIR HEATER

Fixed Parabolic Reflector: Cost Rs 5,000/m², Weight 5 to 10 kg/m²

*Air In/Out 29/190 to 298 C, Heat Duty 0.3 to 0.685 kW/m², Air Flow 200 lpm/m², Efficiency 45 to 60%
Isolation 0.75 to 1.2 kW/m²*





EVACUATED GLASS TUBE SOLAR AIR HEATER

Fixed Parabolic Reflector: Cost Rs 5,000/m², Weight 5 to 10 kg/m²

*Air In/Out 29/150 to 298 C, Heat Duty 0.3 to 0.375 kW/m², Air Flow 100 lpm/m², Efficiency 45 to 60%
Isolation 0.75 to 1.2 kW/m²*





EVCUATED GLASS TUBE SOLAR AIR HEATER

Applications for Cost Light Weight Collectors

- ***Domestic Applications***

- ✓ ***Water heating (30 to 90 C or 180 C if pressurized)***
- ✓ ***Residential or commercial space heating (30 C or above as per need)***
- ✓ ***Domestic / community solar cooking (180 to 250 C)***
- ✓ ***Solar Refrigeration (up to - 20 C or 30 to 95 C in generator)***
- ✓ ***Solar Comfort Air Conditioning (23 to 27 C)***

- ***Industrial Applications***

- ✓ ***Crop / fruit / bio-products drying (40 to 100 C)***
- ✓ ***Industrial air conditioning (Automobile, textile, sugar mill etc 24 to 27 C)***
- ✓ ***Desalination / salt production (60 to 110 C)***
- ✓ ***Solar thermal steam / power generation (95 to 250 C)***
- ✓ ***Boiler fuel / air pre-heating (~ 65 to 180 C)***
- ✓ ***In automobile paint drying in shop (~ 90 to 150 C)***
- ✓ ***Industrial process heating (up to 275 C)***
- ✓ ***Process steam generation in textile / chemical / sugar industries (95 to 250 C)***



EVACUATED GLASS TUBE SOLAR AIR HEATER

Characteristic Features

Aperture area, $A_{sc.ap}$	2.1 m ² (0.311 m x 1.71 m)
Absorber area, $A_{ab.EGT}$	0.2525 m ²
Latitude, ϕ	19.1° (Bombay)
Collector tilt angle, β	$\phi - \delta$ (δ – declination angle)
EGT absorber diameter, $d_{igt.o}$	47 mm, inner tube outer surface
EGT cover diameter, $d_{ogt.o}$	57 mm, Boro-silicate glass tube
Heat enhancing fin assembly	Stainless Steel-304, Fin and holding springs
Photo-voltaic panel	12.3 W _p (Peak power)
San Ace 40 counter - rotating fan	13.2 W / 12 V DC, 40 mm x 56 mm size
Insolation, I_T measuring instrument	Suryamapi
Magnehelic pressure gauge range	0 to 10 and 0 to 50 mm _{H₂O} (water column)
Air Header, SS-square tube	SS-304, 100 Sq x 1.5 thick x 1195 mm Long x 1 number
Parabolic trough supporter arc-strips	SS-304, 20 width x 2.0 thick x 460 mm Long x 12 nos
Parabolic concentrator	0.3 mm thick Al - film reflector with polyester sheet
Concentric air tube outer diameter, $d_{at.o}$	SS-304, 31.75 & 25.4 $d_{at.o}$ x 0.9 thick x 1860 mm L x 8 nos



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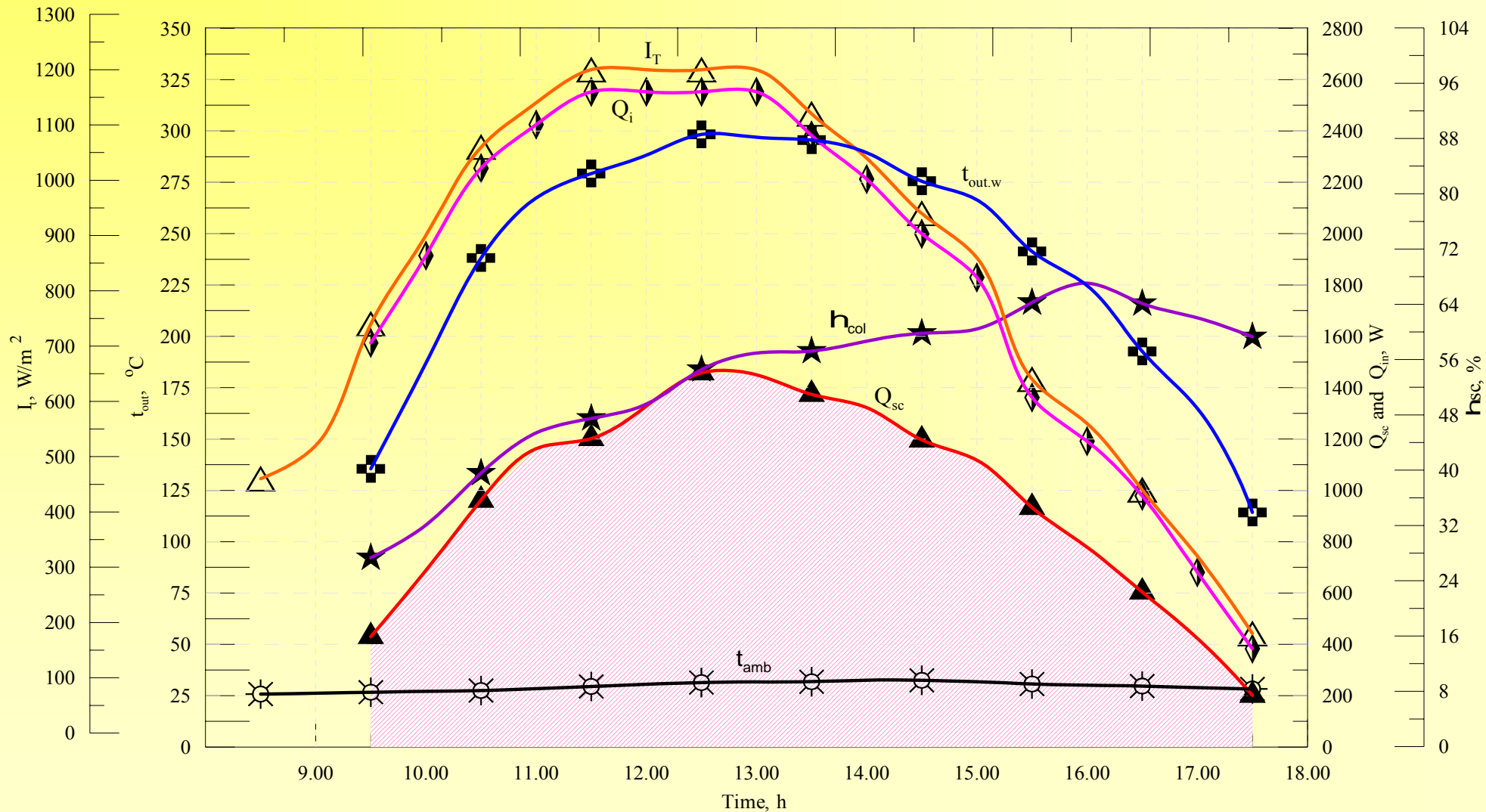
Observation and Result Data (3/03/2007)

Time	t_{amb}	$t_{out.w}$	dp_{pt}	W_p	I_T	$volf_a$	m_a	Q_{col}	Q_i	Q_{col_30}	Q_{i_30}	$\square_{col.w}$		
h	C	C	mm H_2O	W	W/m ²	lpm	g/s	W	W	kJ	kJ	%		
9.30	26.7	135.5	1.2	4.98	740	274.4	3.94	430.4	1574.2	387	1417	27		
10.30	27.5	238.2	2.0	6.65	1060	396.2	4.54	962.0	2254.9	1485	3753	40		
11.30	29.5	279.3	2.4	7.56	1200	451.1	4.79	1202.1	2552.8	2128	4480	47		
12.30	31.4	298.4	3.2	7.61	1200	529.8	5.43	1458.8	2552.8	2508	4595	55		
13.30	31.8	295.6	2.9	8.80	1120	502.9	5.18	1374.9	2382.6	2543	4442	57		
14.30	32.5	275.5	2.5	5.88	940	458.6	4.90	1196.9	1999.7	2268	3791	60		
15.30	30.7	241.3	1.9	4.15	640	386.9	4.41	933.4	1361.5	1846	2872	64		
16.30	29.7	192.6	1.2	1.83	440	292.9	3.68	603.7	978.6	1244	1800	64		
17.30	28.3	144.2	0.4	1.00	180	154.2	2.33	201.9	389.4	564	919	59		
										181	345	53		
										Total Heat (kJ)		29948.7	56135.2	53.4
										Total Heat (kWh)		8.32	15.6	
Avrg ^{6h}	30.7	271.8	2.5	6.68	1013	454.8	4.88	1190.8	2155.7	2136.7	3934.4	54.3		



EVACUATED GLASS TUBE SOLAR AIR HEATER

Performance Analysis: Results Presentation





CONCLUSION

- ***Modular Construction Suitable for***
 - ✓ ***Residential, commercial and industrial applications***
 - ✓ ***In the temperature range of 150 to 300 C***
- ***EGT_SAHwPR Operating Under Forced Convection***
 - ✓ ***Delivers hot air of 200 to 300 C with 5 to 8 kWh / day collection***
 - ✓ ***$\eta = 45$ to 55 % in clear sunny days *with weekly sun-tracking****
- ***Ambient Air was Blown into Collector by***
 - ✓ ***13.2 W / 12 V counter-rotating DC fan of 40 mm x 56 mm x 81 mm***
 - ✓ ***Powered with 12.3 W_p PV panel,***
 - ✓ ***System can operate in remote off-grid locations***
- ***PV Powered DC fan Modulates Air Flow Rate***
- ***Techno-Economically Viable System which can be Mounted on Existing Roof Structures***