“Building Integrated photovoltaics with cost effective cooling”

Karantagli Eleni
(Ms Environmental Science Dep. University of Patras)
Tripanagnostopoulos Georgios
(Material Science Dep. University of Patras)

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What is therefore, more obvious than to cool the modules in order to increase efficiency?

Temperature of PV

Efficiency of PV

Two technologies in one module

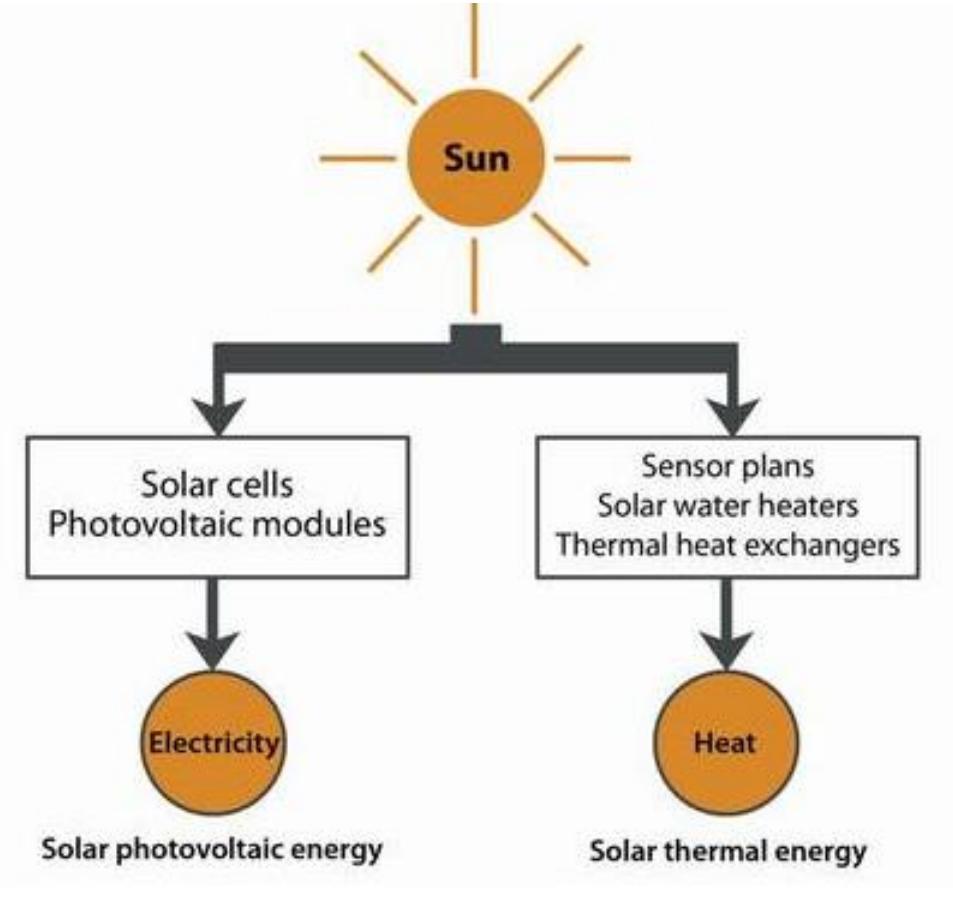
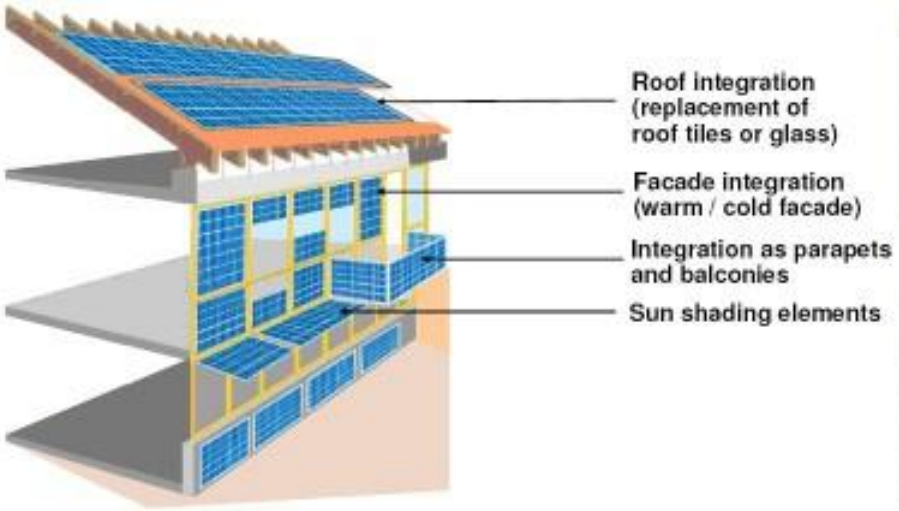
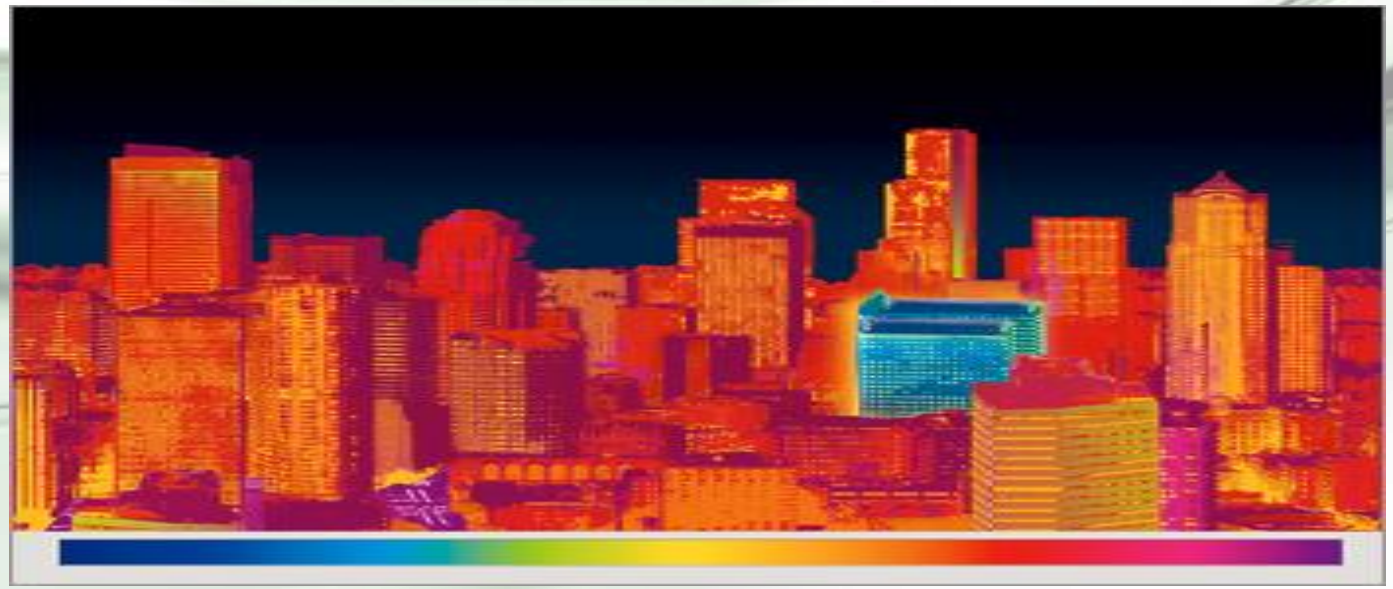


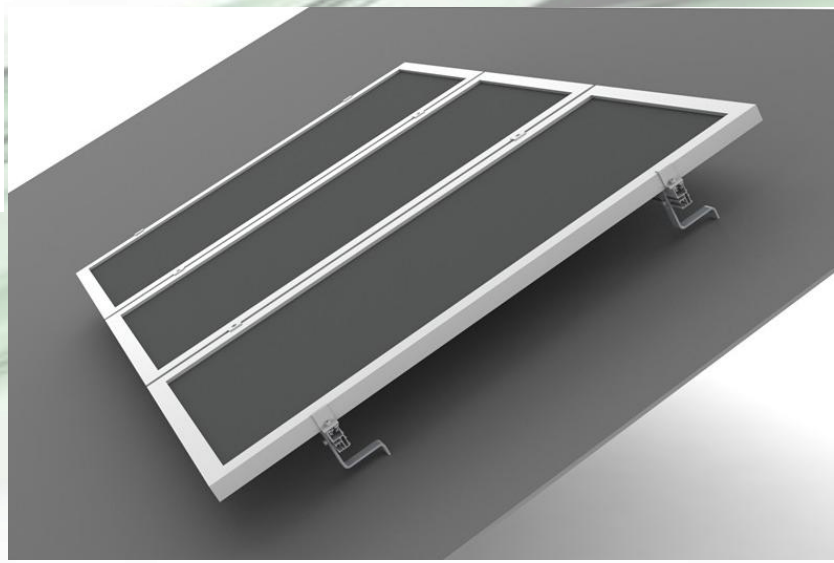

Photo by Centrosolar


Roof integration
(replacement of
roof tiles or glass)
Facade integration
(warm / cold facade)
Integration as parapets
and balconies
Sun shading elements

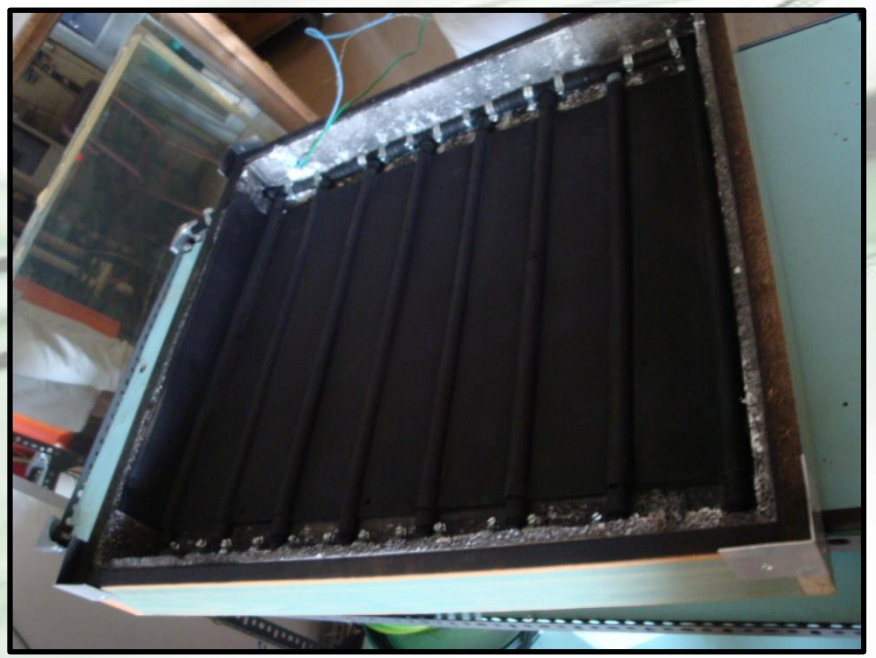


In addition, heat from PV modules is transmitted to the building, mainly during summer, the building temperature rises over the acceptable comfort level and more electrical energy is needed to cover the increased load of the air conditioning system to reject this undesirable heat out to the ambient and to cool the building.

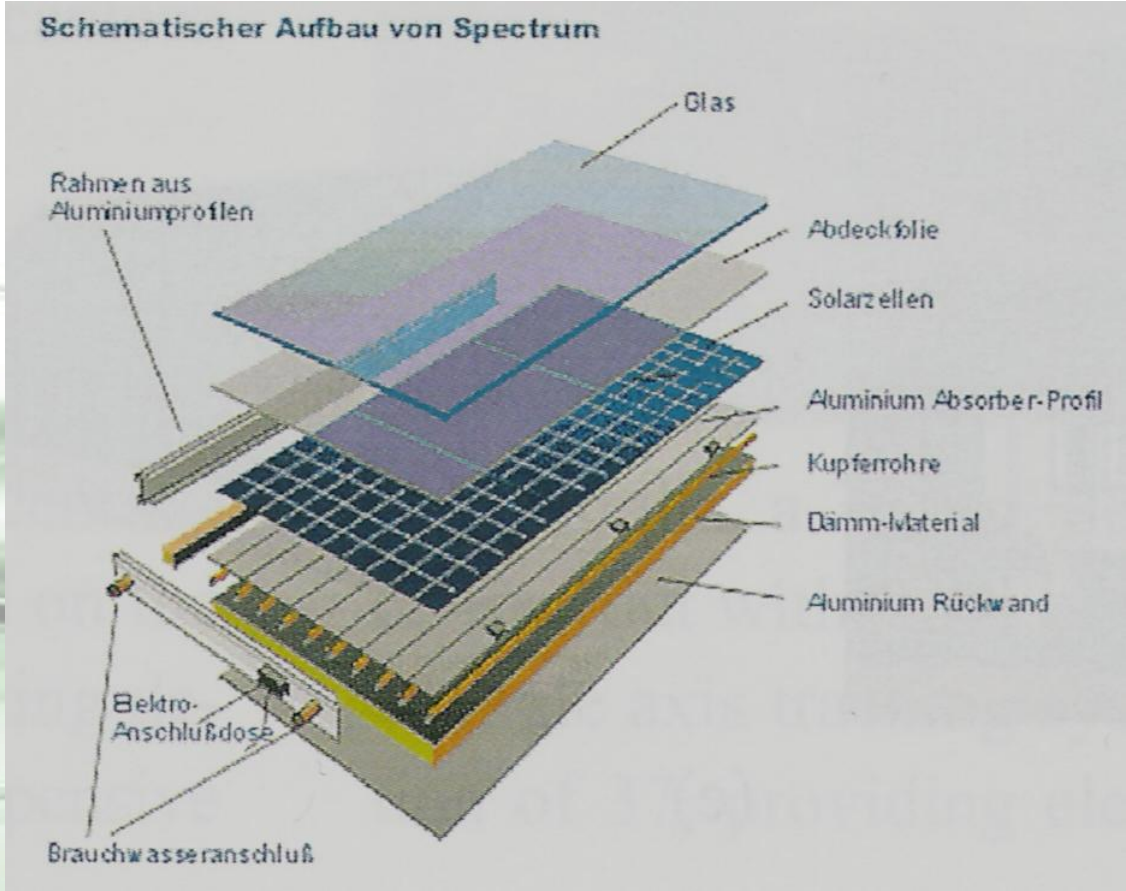
Also, during the installation of PV on the roof there is an empty space, about 10 cm, which will take advantage of, for our purpose.

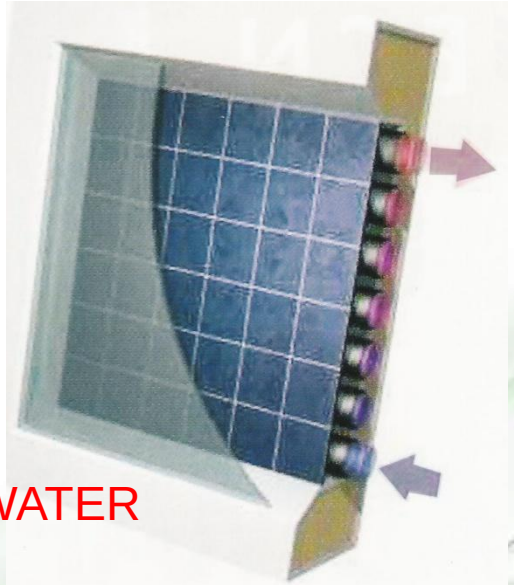


“Heat Removal Unit”
(HRU)



Hybrid Photovoltaic/Thermal Solar Energy Systems





PVT/WATER

PVT/AIR

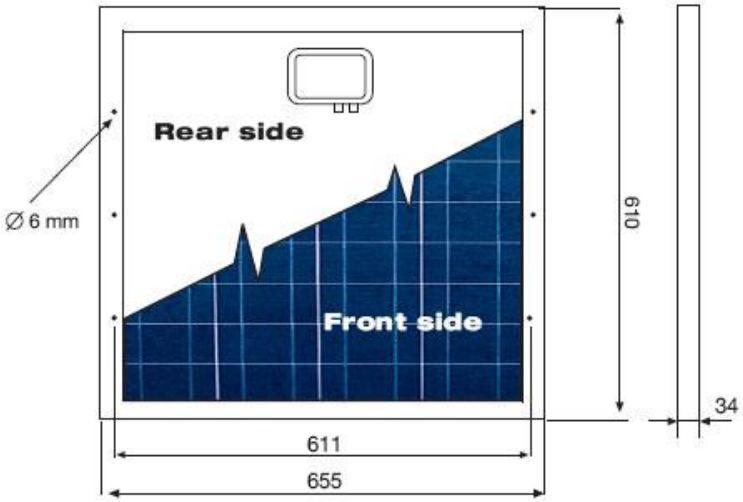
MODEL CONSTRUCTION

PV's characteristics

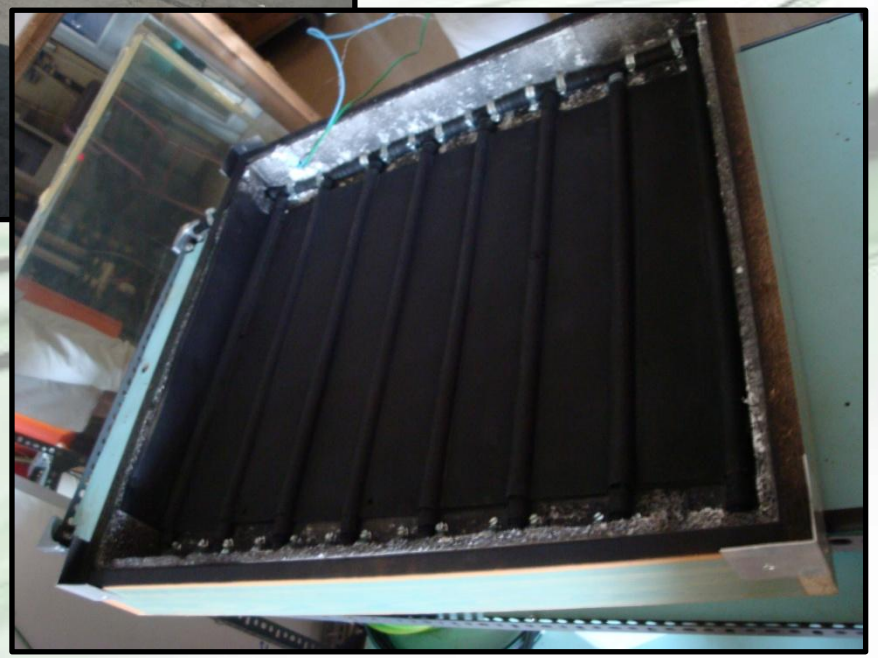
Conergy Q 50PI

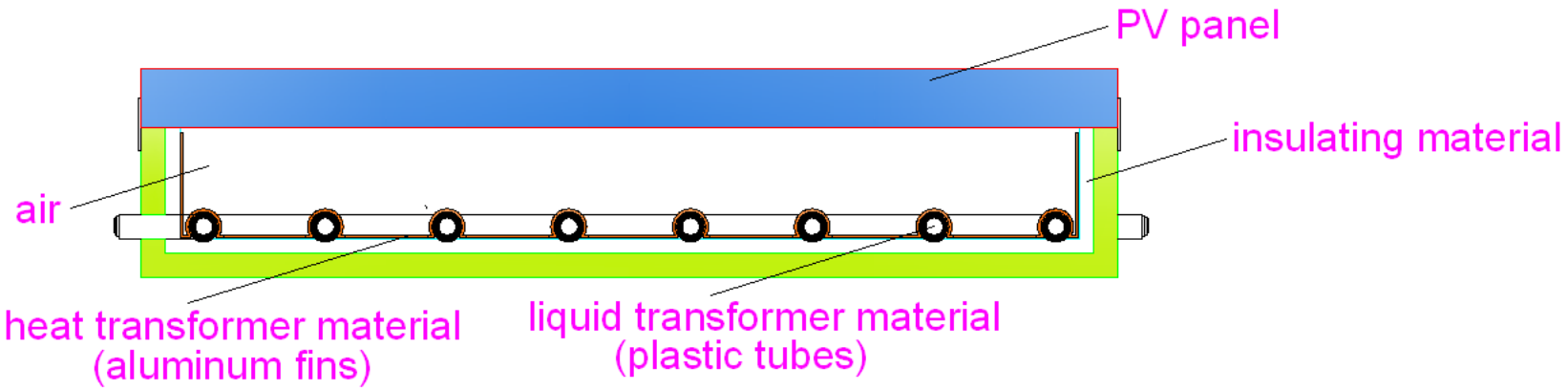
Maximum Power (P_{MPP})	50W
Tolerance of Power	+/-5%
Rated Voltage (V_{MPP})	16.5V
Rated Current (I_{MPP})	3.05A
Open Circuit Voltage(V_{oc})	20.0V
Open Circuit Current (I_{sc})	3.47A
Maximum System Voltage	600V

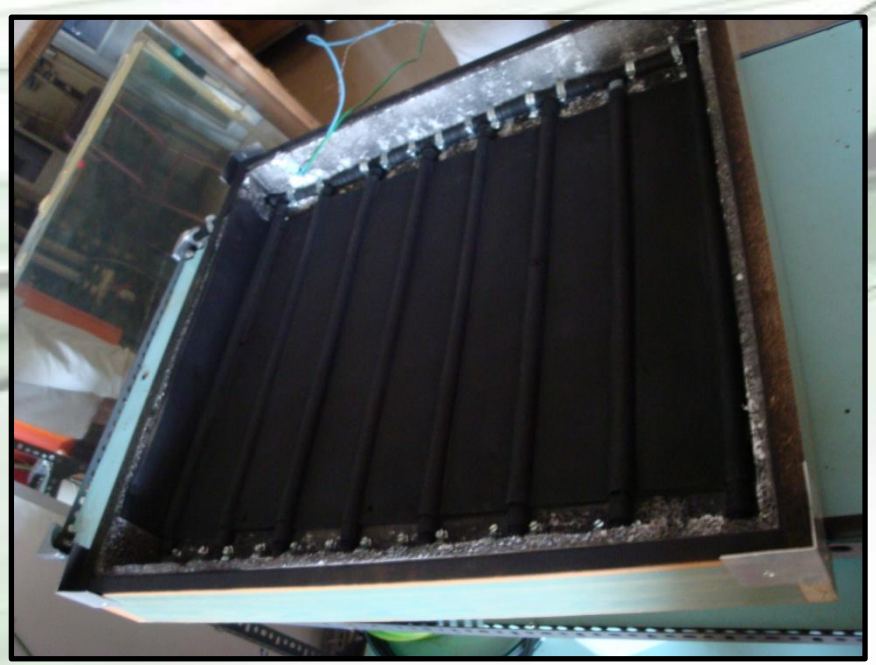
(insol. 1000W/m² AM 1.5 CEL T. 25°C)

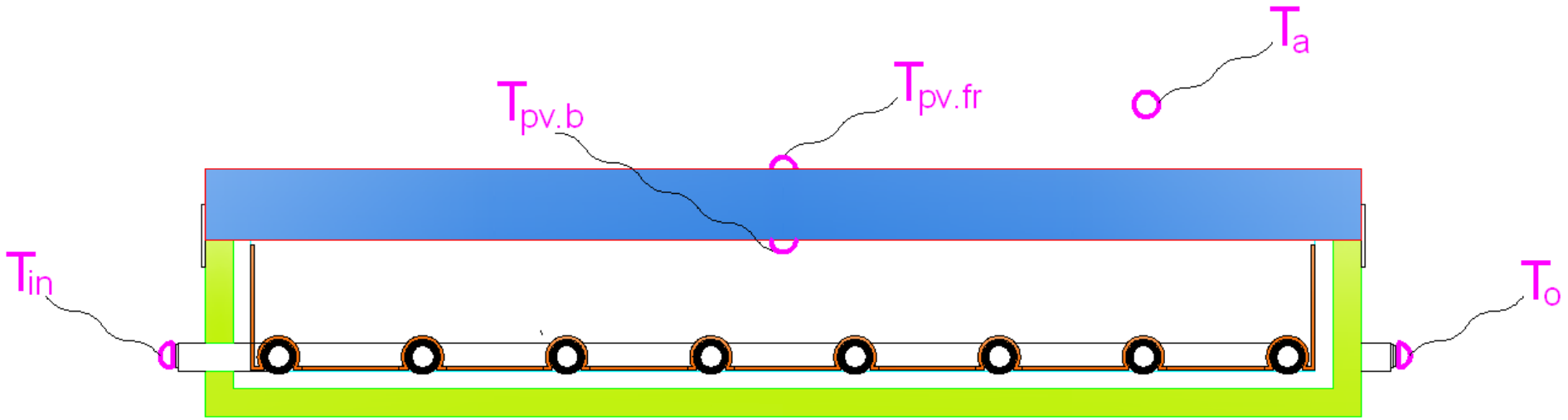


All dimensions in mm




PV panel
insulating material
air
heat transformer material
(aluminum fins)
liquid transformer material
(plastic tubes)

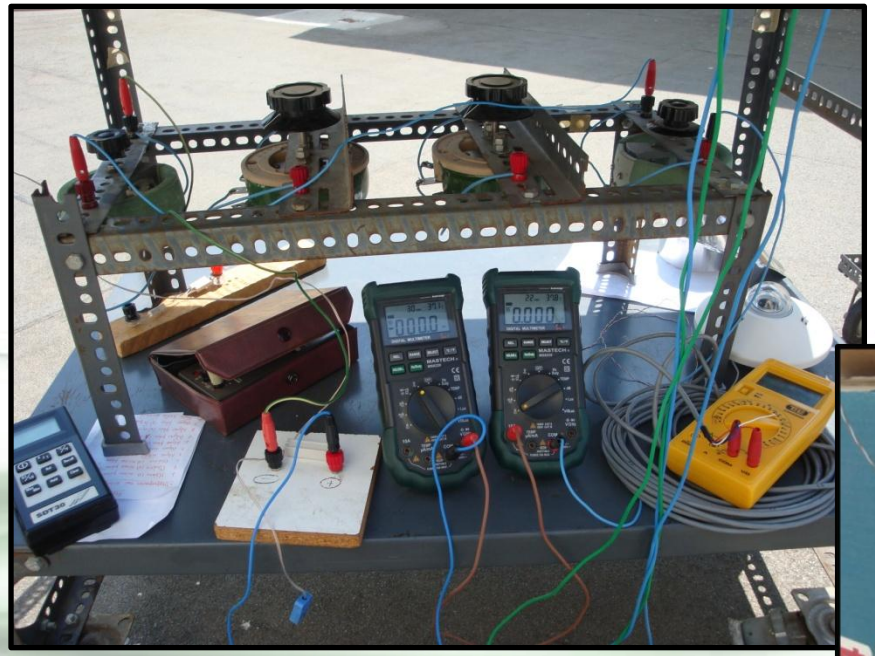




Thermocouples

Experimental instruments

- Equipment:



I-V system

Pyranometer

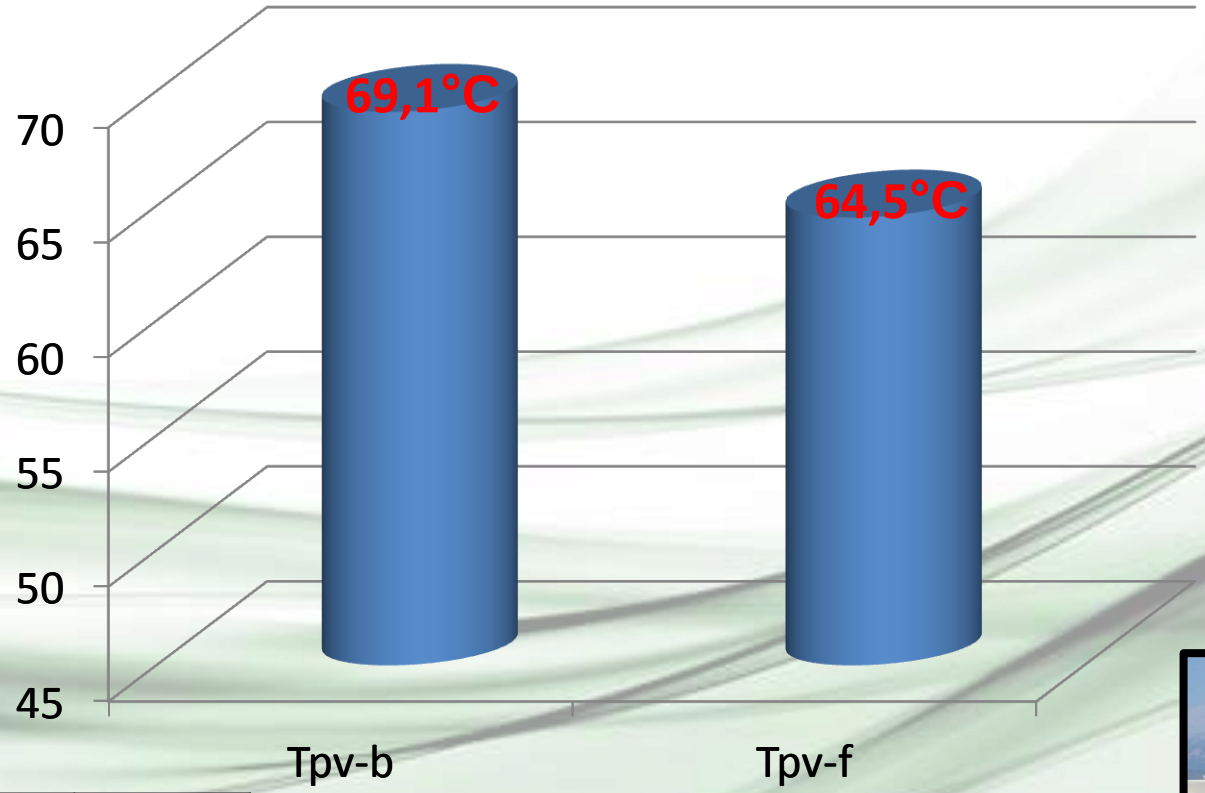
Temperature sensor

Azimuth 30º

Connection to water net

Experimental Procedure

First Stage:

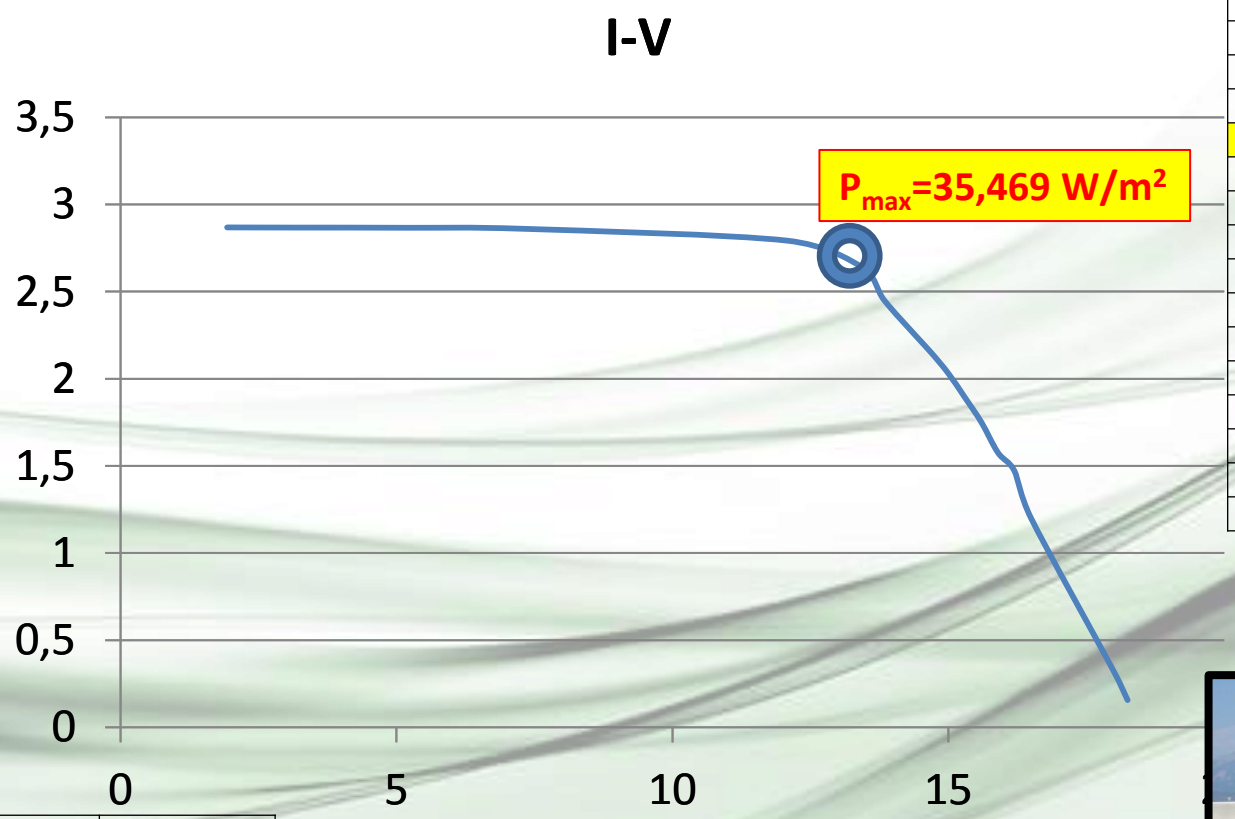


	Tpv-f(°C)	Tpv-b(°C)
12:25	46	49
13:15	62,5	68,1
13:37	63,5	68,5
13:41	64,5	69,1

Ir(W/m2)	Ta(°C)
937,02	33,5

Experimental Procedure

First Stage:



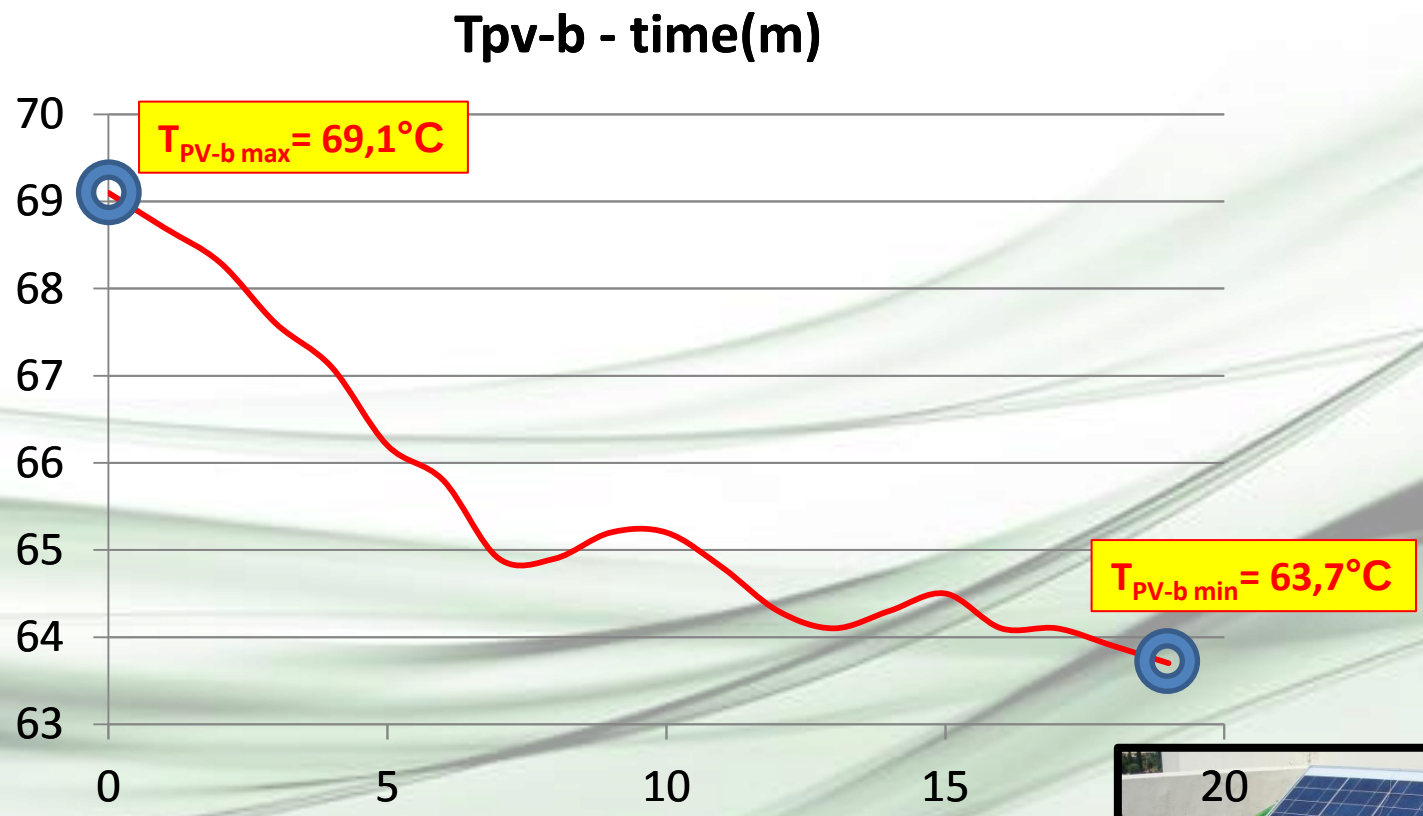
V(V)	I(A)	P(W)
1,93	2,868	5,5
3,21	2,867	9,2
5,19	2,866	14,9
7,3	2,86	20,9
12,08	2,792	33,7
13,42	**2,643**	**35,5**
13,84	2,45	33,9
14,4	2,25	32,4
14,7	2,146	31,5
15	2,031	30,5
15,3	1,893	29,0
15,6	1,75	27,3
15,9	1,576	25,1
16,2	1,47	23,8
16,5	1,2	19,8
18	0,321	5,8
18,25	0,156	2,8

	Tpv-f(°C)	Tpv-b(°C)
12:25	46	49
13:15	62,5	68,1
13:37	63,5	68,5
13:41	64,5	69,1

Ir(W/m2)	Ta(°C)
937,02	33,5

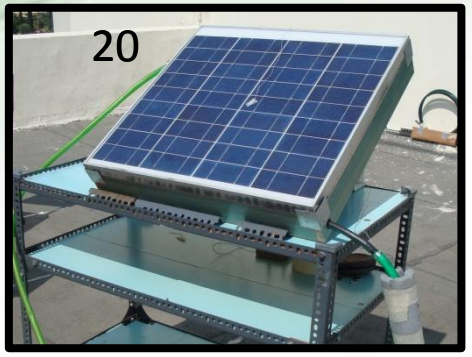
Experimental Procedure

Second Stage:



	Tin(°C)	Tout(°C)	Tpv-f(°C)	Tpv-b(°C)
14:00	25,2	27,7	60,4	63,7

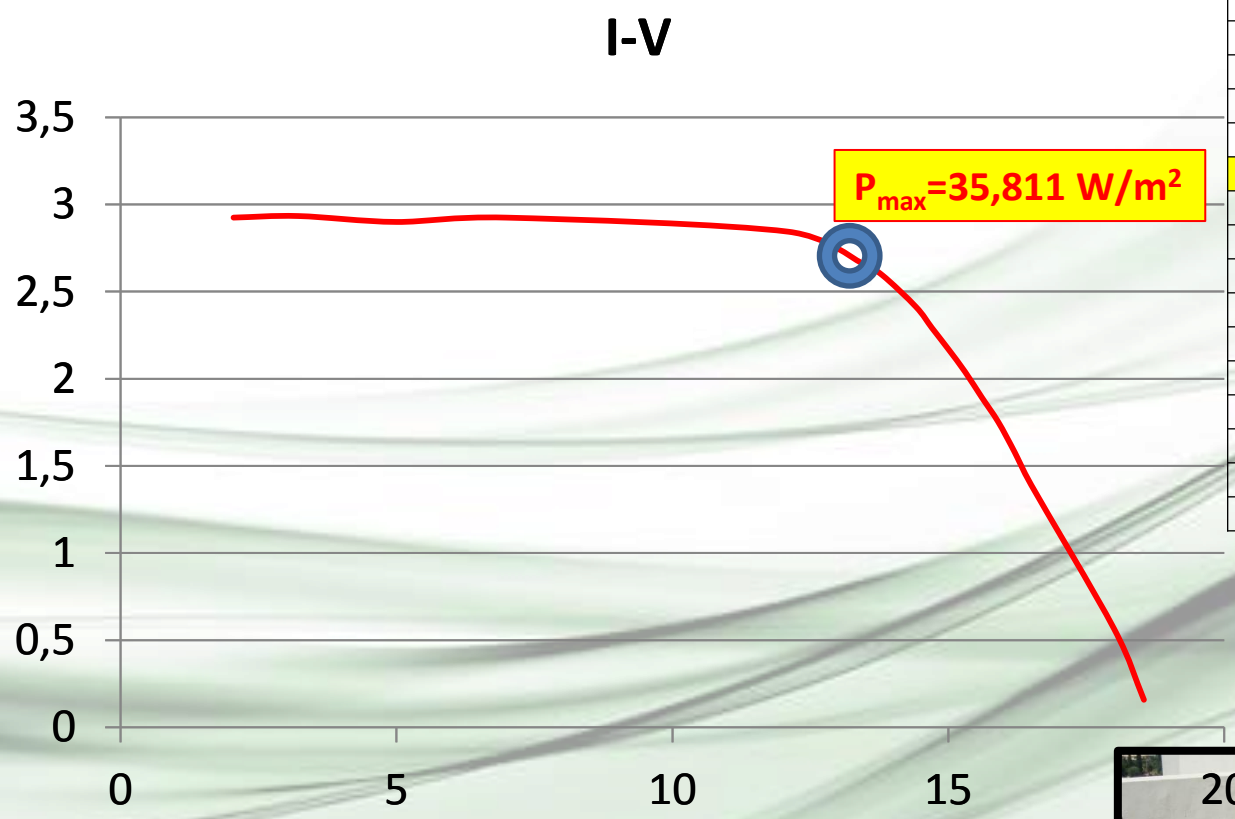
Ir(W/m2)	Ta(°C)	flow
898,62	34,2	0,0119kg/s

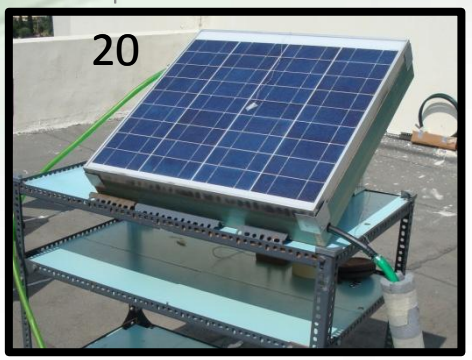


Experimental Procedure

Second Stage:

V(V)	I(A)	P(W)
2,047	2,925	6,0
3,22	2,934	9,4
5	2,9	14,5
6,98	2,925	20,4
12,1	2,844	34,4
13,42	2,666	35,778
13,8	**2,595**	**35,811**
14,41	2,413	34,8
14,7	2,292	33,7
15	2,169	32,5
15,3	2,04	31,2
15,6	1,895	29,6
15,9	1,753	27,9
16,2	1,578	25,6
16,5	1,39	23,0
18	0,565	10,2
18,54	0,158	3.0



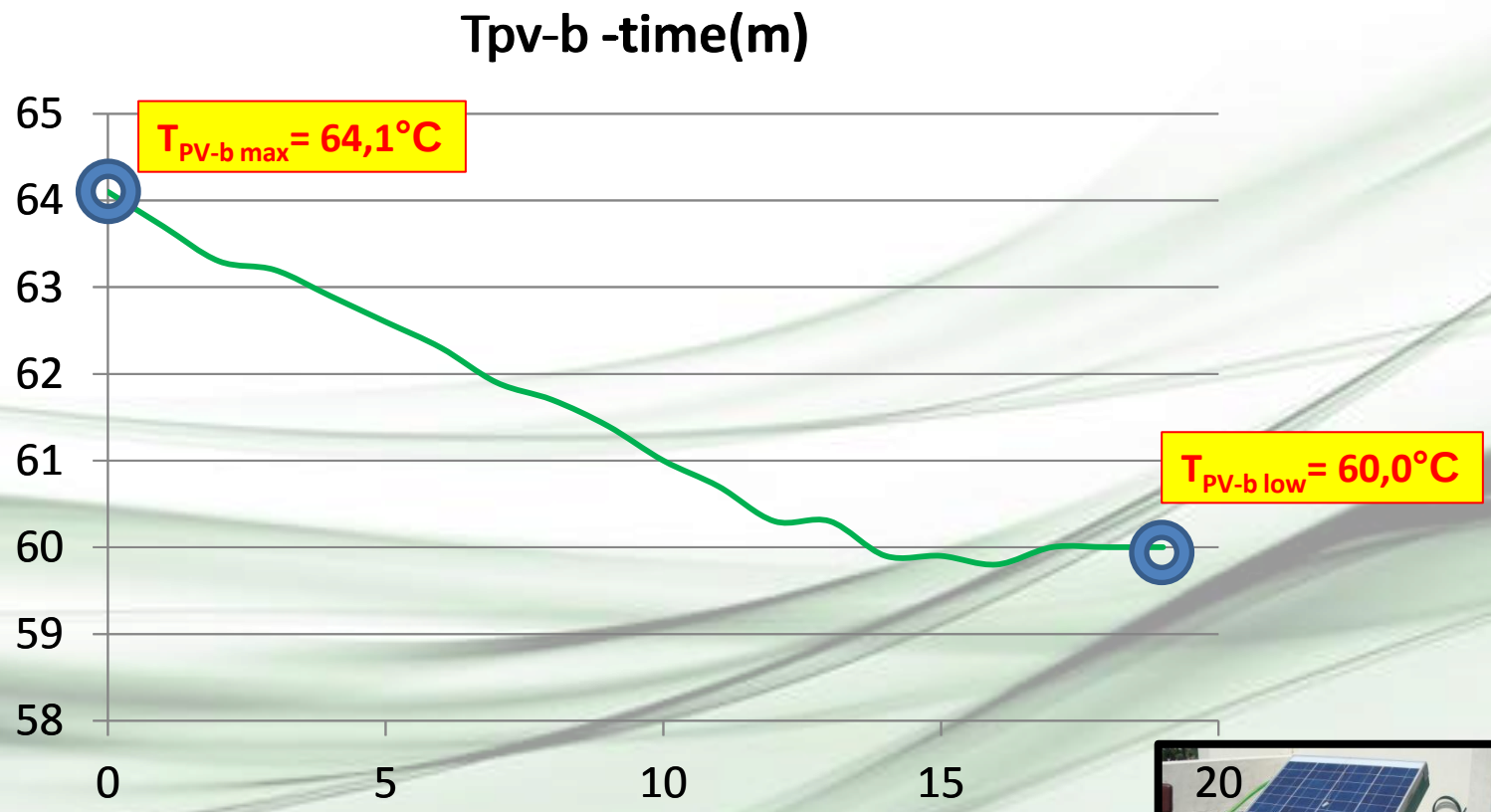


	Tin(°C)	Tout(°C)	Tpv-f(°C)	Tpv-b(°C)
14:13	25,8	26,8	61,3	64

Ir(W/m2)	Ta(°C)	flow
898,62	34,2	0,0119kg/s

Experimental Procedure

Third Stage:

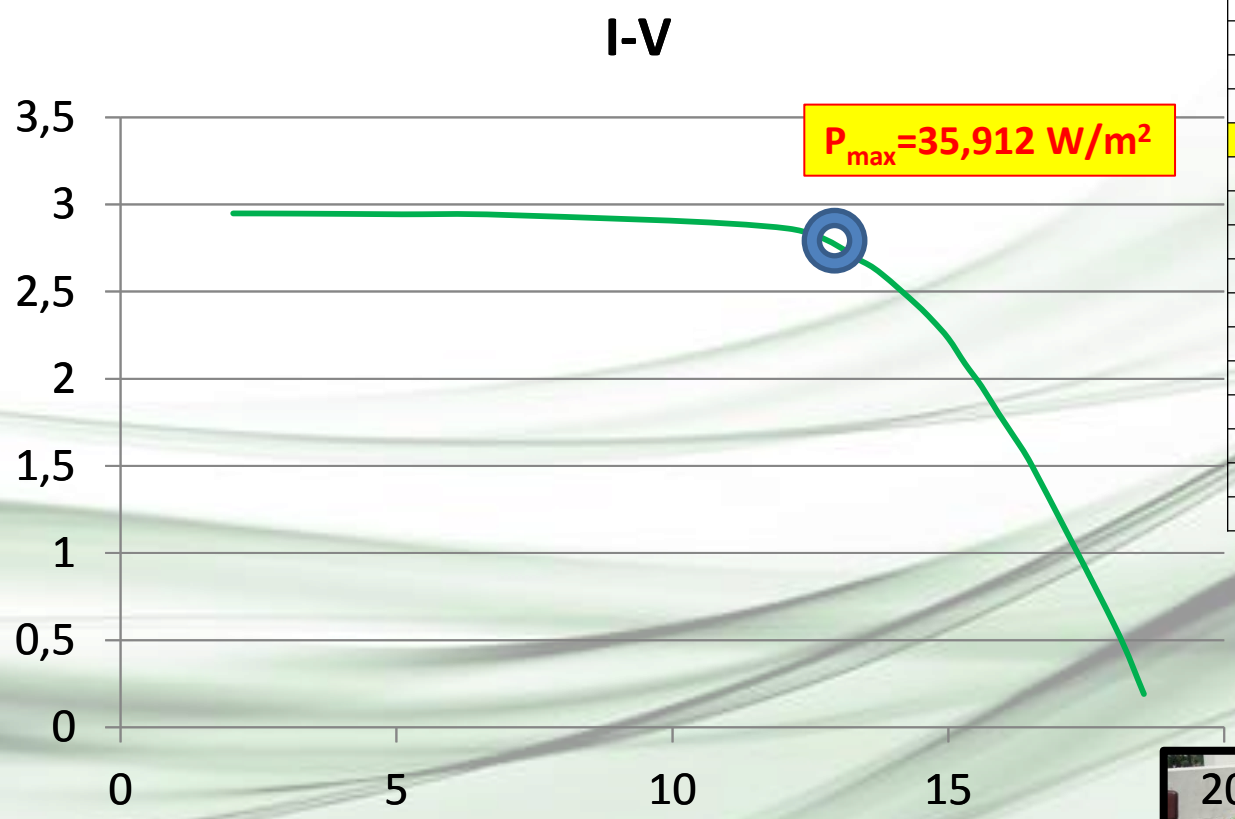


	Tin(°C)	Tout(°C)	Tpv-f(°C)	Tpv-b(°C)
14:35	23,5	24,1	58,0	60,0
14:43	22,8	23,7	59,0	60,3

Ir(W/m2)	Ta(°C)	flow
867,9	34,9	0,0334kg/s

Experimental Procedure

Third Stage:



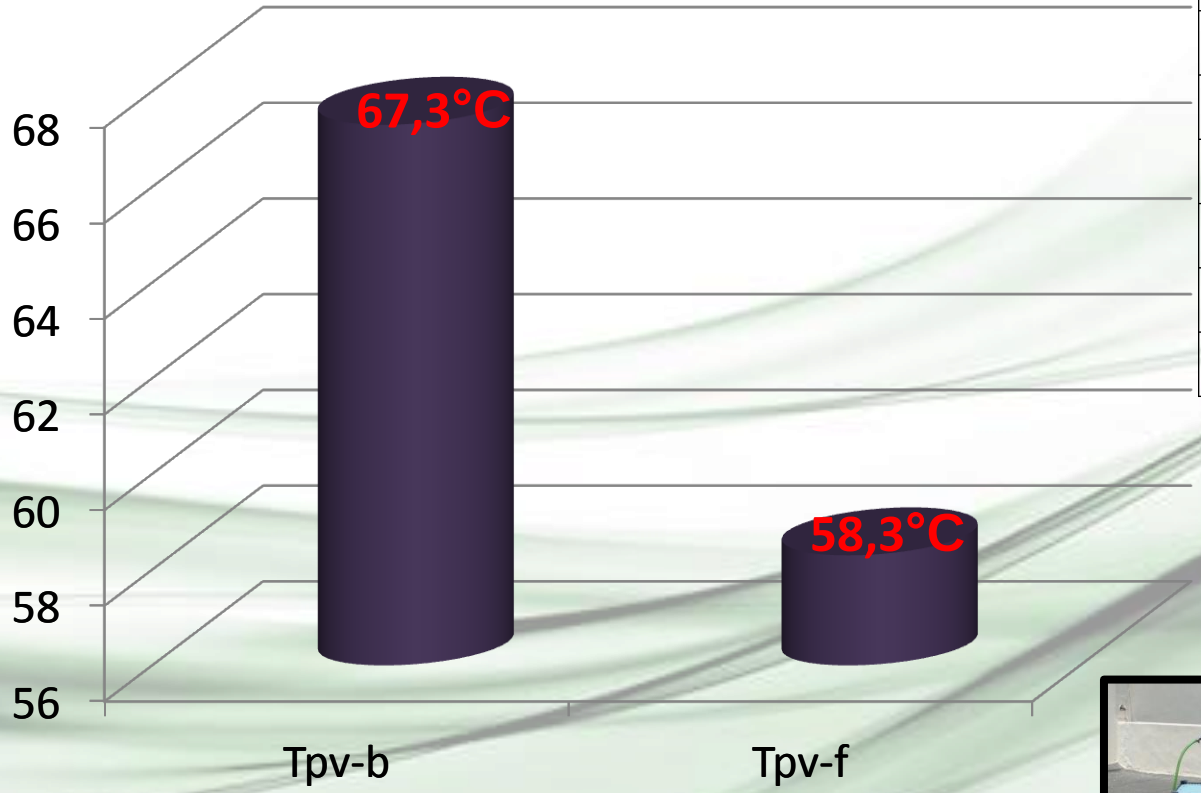
V(V)	I(A)	P(W)
2,044	2,948	6,0
3,21	2,947	9,5
5,1	2,943	15,0
6,98	2,939	20,5
12,1	2,861	34,6
13,44	**2,672**	**35,912**
13,8	2,598	35,852
14,42	2,426	34,983
14,7	2,338	34,4
15	2,23	33,5
15,3	2,086	31,9
15,6	1,956	30,5
15,9	1,804	28,7
16,2	1,661	26,9
16,5	1,508	24,9
18	0,589	10,6
18,54	0,191	3,5

	Tin(°C)	Tout(°C)	Tpv-f(°C)	Tpv-b(°C)
14:35	23,5	24,1	58,0	60,0
14:43	22,8	23,7	59,0	60,3

Ir(W/m2)	Ta(°C)	flow
867,9	34,9	0,0334kg/s

Experimental Procedure

Forth Stage:

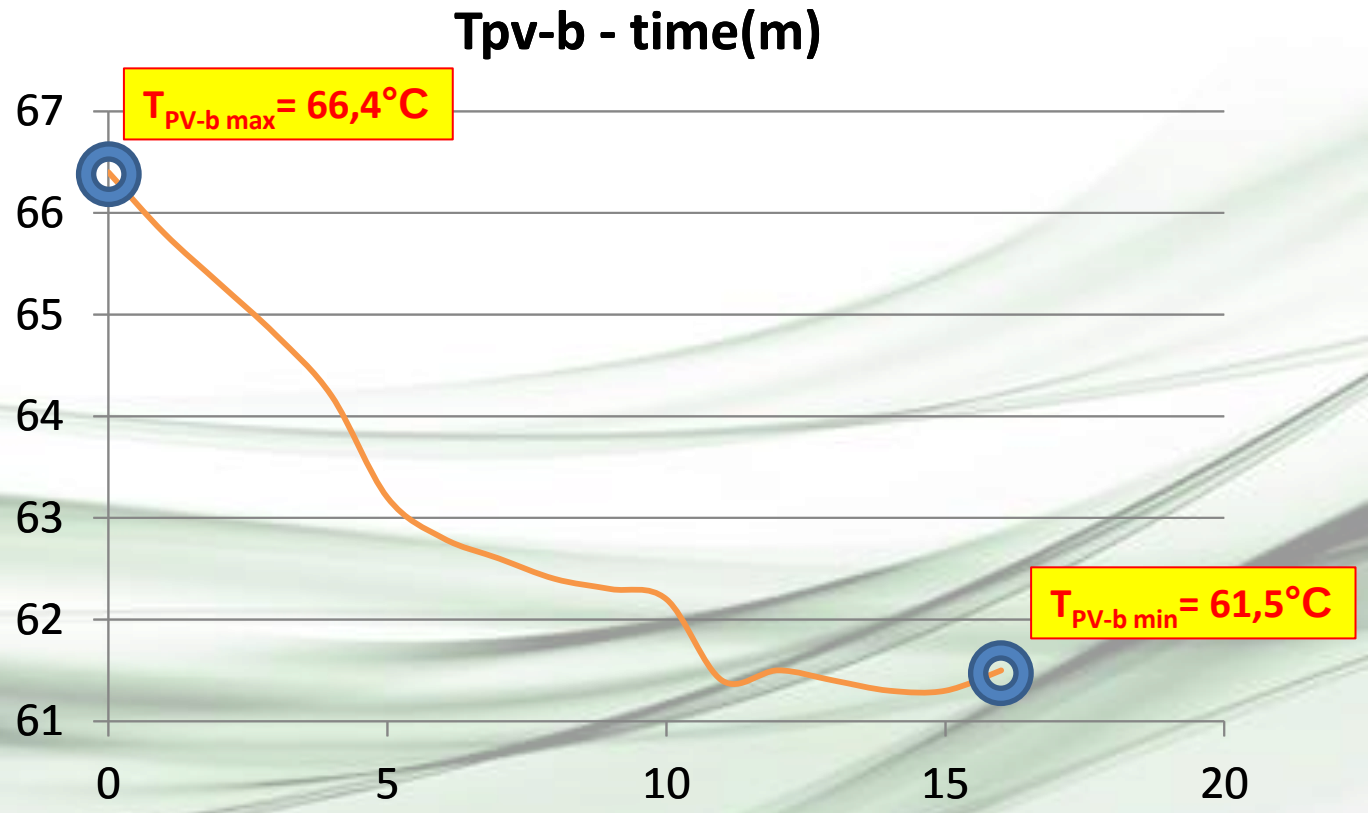


	Tpv-f (°C)	Tpv-b (°C)
14:55	57	61
15:00	57,7	63,2
15:05	58,5	65,5
15:10	61,3	66,4
15:15	59,5	67
15:20	59,1	67,5
15:25	58,3	67,3

Ir(W/m2)	Ta(°C)
937,02	33,3

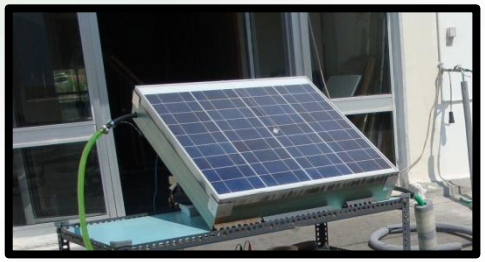
Experimental Procedure

Fifth Stage:



	Tin(°C)	Tout(°C)	Tpv-f(°C)	Tpv-b(°C)
15:31	23,3	24,5	-	63,2
15:43	23,3	24,4	56,1	61,5

Ir(W/m2)	Ta(°C)	flow
898,62	32,0	0,0119kg/s



Conclusions

- We observed a considerably reduction of PV temperature, which resulted an electrical efficiency improvement from 11,1% (without water flow) to 12.2% (with water flow).
- The second observation was the higher flow rate resulted to better cooling effect and in shorter time.
- On the opposite the higher flow rate of water resulted to lower temperature rise of it.

Suggestments - Improvements

- Decrease the distance between HRU and PV's back side
- Increase of HRU surface
- The water circulation pipes of HRU could be metallic instead of plastic, but we must consider the additions of the cost
- To adapt a real installation on building inclined roof the suggested system should be tested with natural air flow under PV module

Thank you for your attention!

Karantagli Lena
(karantagli@upatras.gr)

Tripanagnostopoulos Georgios
(dalee_geo@yahoo.gr)