Project is supported by

PVT collector for combined heat and power generation,

Ilija Nasov, PhD,

CEO of Plasma

President of board of directors of Camel Solar

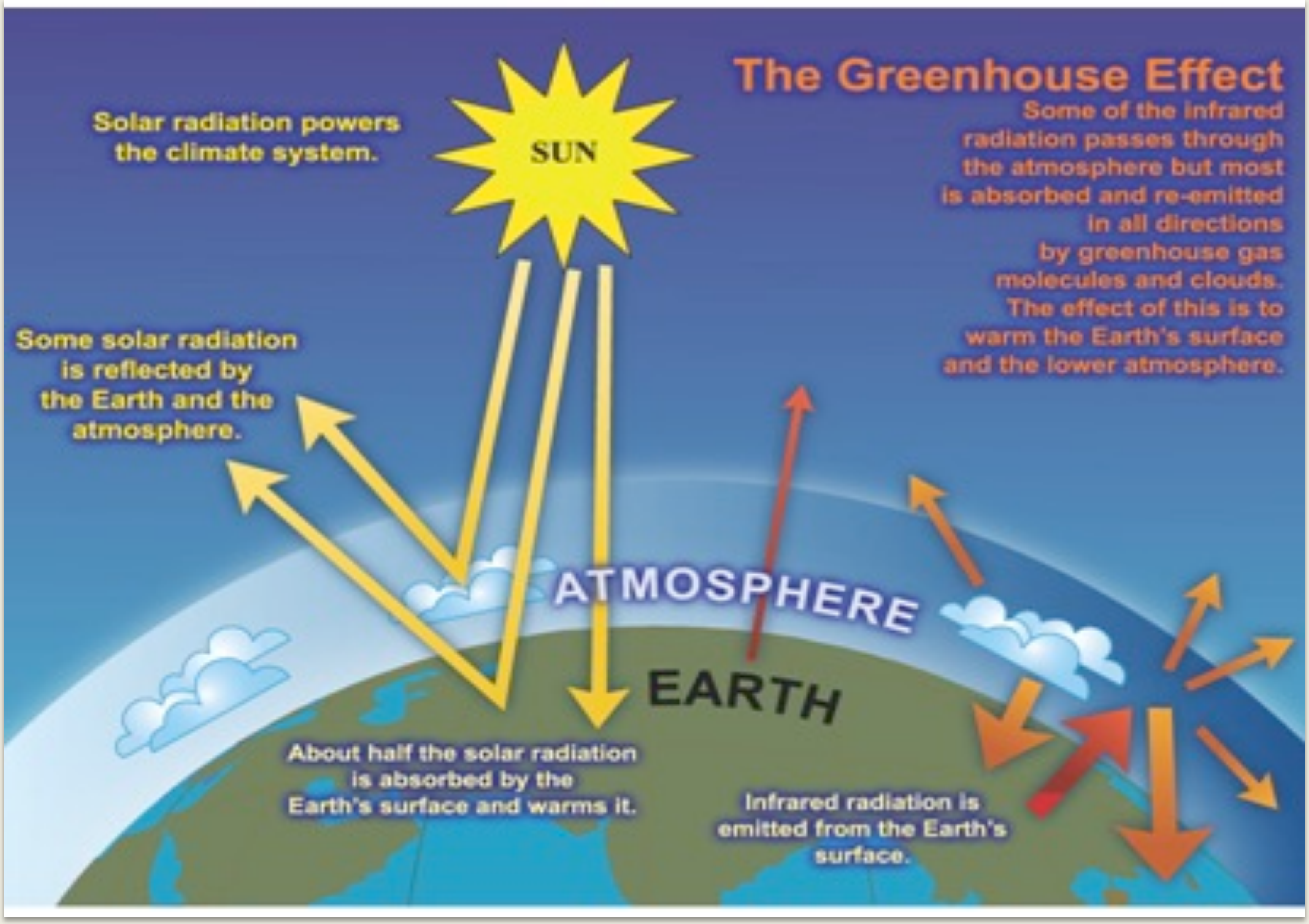
ilija@camel-solar.com

Нај сериозни преокупации на денешницата: климатските промени и глобалното затоплување

1.Состојба,причини и последици
2.Решавање: обновливи извори на енергија
3.Сончева енергија

Prf.Dr. Ilija Nasov
Camel Solar
070 205 635

CLIMATE CHANGE



An idealized model of the natural greenhouse effect.

CO_2 емисиите по жител треба да се редуцират од 4.1 тон   до 2008 год.на помалку од 1.3 t до 2050 год. со цел да не се надмине договорениот лимит на 2 ^{0}C. Ова подрзбира редукција на емисијата на стакленичките гасови од 53 до 83%. помеѓу 2008 and 2050

Редукцијата на CO_2 и останатите стакленички гасови не се единствените директиви , туку и загадувањето на воздухот и водата и екосистемот....и адаптирање на енергетските извори

Adaption and mitigation

На кој начин да се решат климатеките промени т.е. глобалното загревање и загадувањето на човековата околина?

Со решавање на причините за глобалното загревање!

Значи со добивање на енергија со најмала емисија на CO_2 и други стакленички гасови како и ПМ честички.

Значи замена на енергијата од фослни со ОИЕ.

Секако дека сончевата енергија е нај еколошката енергија во однос на сите други ОИЕ.

ПРИНЦИП:

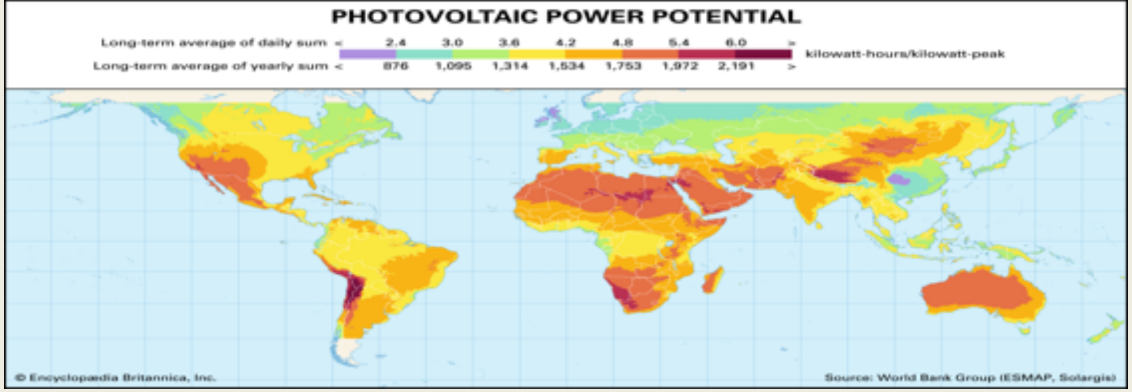
CO_2/ kWh добиене енерг. или ПМ чест./kWh добиена енерг.

Вкупната енергија што доаѓа кон Земјата ($1.73 \cdot 10^{17}$ W) односно $1.5 \cdot 10^{21}$ Wh/god

Оваа енергија е околу 8 000 пати поголема од вкупните потреби за енергија на земјата или за еден час од сонцето пристигнува енергија која ги задоволува вкупните потреби за енергија на земјата.

Треба само да сакаме и да знаеме да ја искористиме

Сончева енергија



Solar energy in North Macedonia

- Solar energy in the World, Eu and North Macedonia
- Applications of solar energy

- Short overview
- New technologies in North Macedonia

Prof Dr. Ilija Nasov
President of Solar Macedonia
Chairman of owners Camel Solar

- -

SOLAR HEAT WORLDWIDE

Around 400,000 thermosiphon systems were built in Brazil as part of the Minha Casa, Minha Vida social housing program. Photo: TUMA

SOLAR HEAT WORLDWIDE

Germany's largest solar district heating system in Ludwigsburg with a capacity of 10 MW_{th} was put into operation in early 2020.

SOLAR HEAT WORLDWIDE

Collector system with 6.5 MW_{th} for heating a greenhouse in Heerhugowaard, Netherlands. The application works as a drain-back system, which means that the collector fluid is water and not glycol. Photo: G2 Energy

One megawatt of cooling capacity using solar thermal energy at a hospital in Managua, Nicaragua Photo: SOLID Solar Energy Systems GmbH

PVT – Photovoltaic-Thermal Systems

Photovoltaic-Thermal (PVT) collectors combine the production of both types of solar energy – solar heat and solar electricity – simultaneously in one collector, thus reaching higher yields per area. This is particularly important if the available roof area is limited, but integrated solar energy concepts are needed to achieve a climate-neutral energy supply for consumers, such as in residential and commercial buildings.

The PVT market is gaining momentum in several European countries. In recent years, a growing number of specialized PVT technology suppliers have entered European markets.

General market overview

Photovoltaic-Thermal (PVT) collectors were included for the first time in the Solar Heat Worldwide report in 2019 and included data from a 2018 market survey carried out by IEA SHC Task 60 PVT Systems. By the end of 2018 more than 1 million m^2 of PVT collectors were installed in over 25 countries.

SHC Task 60 PVT Systems[12] carried out this survey again in 2019 with responses from 31 PVT collector manufactures and PVT system suppliers in 12 different countries. In 2019, the total installed PVT collector area was 1,166,888 m^2 (606 MW_{th},

Distribution by type of application

In 2019, suppliers of PVT technology commissioned at least 2,800 new PVT systems worldwide. The cumulated number of PVT systems in operation at the end of 2019 was 25,823. The break down is 86% for solar air(pre)heating and cooling of buildings followed by 7% for domestic hot water preparation for single family houses and 4% for solar combi-systems that supply both domestic hot water and space heating. Around 1% of the total installed capacity provided heat and electricity to large domestic hot water systems for multifamily houses, hotels, hospitals, schools, etc. The remaining systems account for around 2% and deliver heat and electricity to other applications, including swimming pool heating, district heating applications and solar heat for industrial applications.

Table 4 shows PVT systems by application.

PVT Applications	Number of installations [#]	Total collector area [m^2]
Swimming pool heating	102	9,449
Domestic hot water systems SFH	1,767	60,588
Large domestic hot water systems	214	133,831
Solar combi systems for SFH	1,087	26,903
Large solar combi systems	265	57,026
Solar air systems	22,317	485,510
Solar district heating systems	20	11,082
Solar heat for industrial applications	51	21,626
Not classifiable		360,877
TOTAL		1,166,888

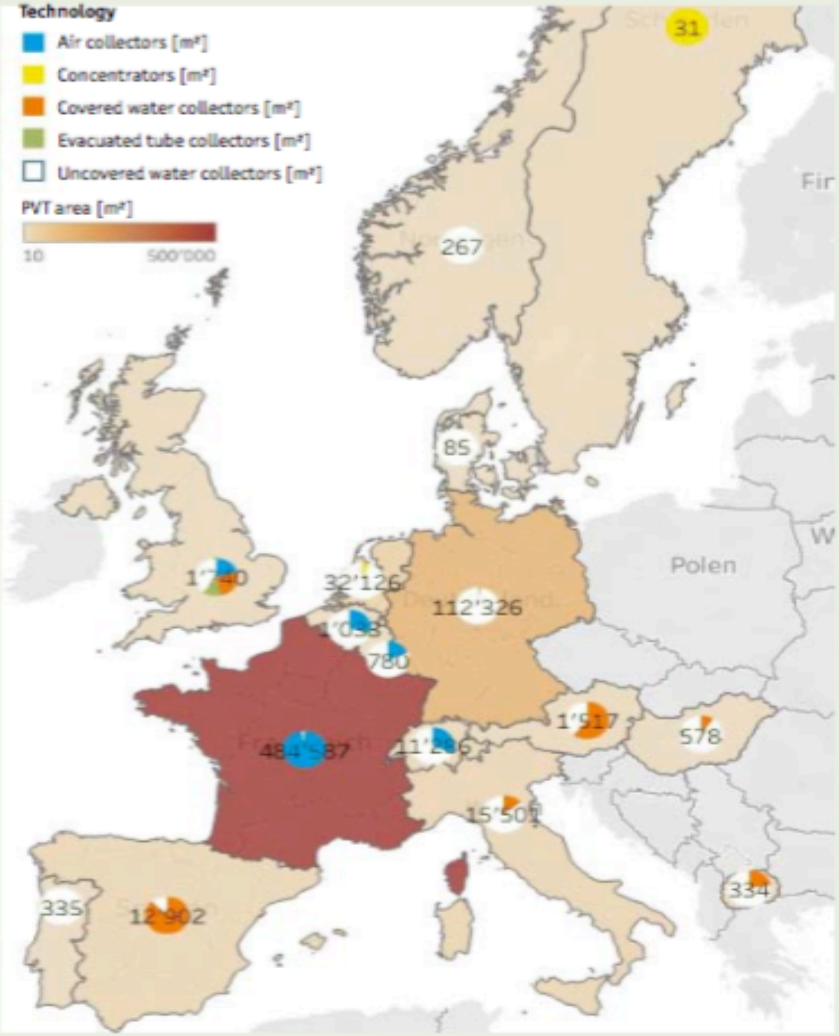
PVT systems by application. (Source: IEA SHC Task 60 survey, AEE INTEC)

Table 2 shows the cumulated installed collector area by PVT collector type at the end of 2019.

Country	Water Collectors [m^2]			Air Collectors [m^2]	Concentators [m^2]	TOTAL [m^2]
	uncovered	covered	evacuated tube			
Australia	523	0	0	24	0	547
Austria	595	922	0	0	0	1,517
Belgium	712	0	16	290	15	1,033
Brazil	26	0	0	0	0	26
Chile	213	101	0	0	10	325
China	133,721	50	0	0	171	133,942
Denmark	85	0	0	0	0	85
Ecuador	0	4	0	0	0	4
Egypt	0	0	0	0	21	21
France	12,619	68	0	471,900	0	484,587
Germany	110,622	1,452	0	87	165	112,326
Ghana	8,000	0	0	0	0	8,000
Hungary	525	53	0	0	0	578
India	0	7	0	0	255	262
Israel	57,488	0	0	0	0	57,488
Italy	13,331	2,170	0	0	0	15,501
Korea, South	280,814	0	0	0	0	280,814
Luxembourg	635	0	0	145	0	780
Macedonia	260	74	0	0	0	334
Maldives	0	0	0	0	21	21
Netherlands	30,353	0	0	0	1,773	32,127
Norway	267	0	0	0	0	267
Pakistan	0	7	0	0	0	7
Paraguey	0	0	0	0	51	51
Portugal	335	0	0	0	0	335
South Africa	0	0	16	0	751	767
Spain	1,552	11,350	0	0	0	12,902
Sweden	0	0	0	0	31	31
Switzerland	7,720	36	0	3,530	0	11,286
United Kingdom	851	312	229	348	0	1,740
United States	5,400	0	0	0	0	5,400
Uruguay	0	2	0	0	0	2
Other	529	3,240	16	0	0	3,785
TOTAL	667,178	19,846	277	476,324	3,263	1,166,888

The following figure shows the total installed collector area and the distribution by PVT technologies by country in 2019 in Europe.

By the end of 2019, the total cumulative thermal capacity of PVT collectors was 606 MW_{th} and the PV power was 208 MW_{peak} installed worldwide. With a global share of 55 % of installed thermal capacity, uncovered PVT water collectors were the dominating PVT technology produced, followed by PVT air collectors with 43 % and covered PVT water collectors with 2 %. Evacuated tube collectors and concentrators play only a minor role in the total numbers.



igure 15: *Total installed collector area and PVT technology in Europe at the end of 2019. (Source: IEA SHC Task 60 survey, AEE INTEC)*

There are several ways of PV installations

1.PV centrals in the fields ***Picture 1***

1

2.PV installations on the roof : private houses, hotels, kindergartens, nursing homes, spa centers, sports halls, stadiums, swimming pools, industrial applications ....

Picture 2

2

3.PV installation's of the facades, roof of parking places, garden.

Picture 3

Except PV centrals in the field ***(picture 1)*** *, end users in the other installation's need electricity and heat. For these applications the most effective way is installing* ***Hybrid Photovoltaic thermal collectors - PVT collectors****.*

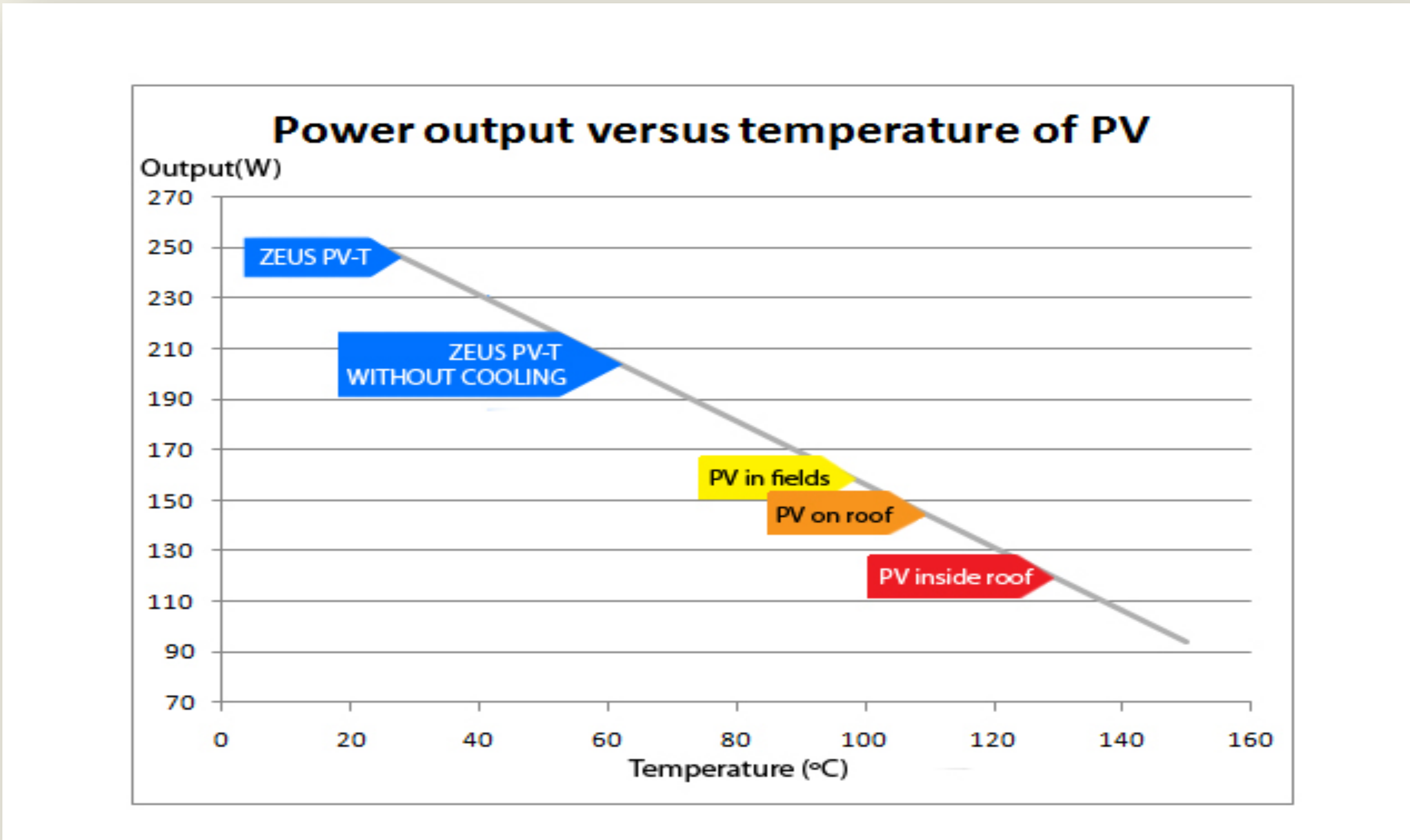
3

Plasma,Camel PVT collector

- **PVT collectors** provide both electrical and thermal energy.
- The greater part of the absorbed solar radiation by photovoltaic is converted into heat (at about 65% -75%), and as result of that is increasing cell temperature. This effect reduces their electrical efficiency.
- In **façade or inclined roof installation** on buildings the thermal losses are reduced due to the thermal protection of back side of PV panels.
- This undesirable effect can be partially avoided by
- **PVT hybrid collector** applying

a suitable heat extraction with a fluid circulation, air or liquid (water), keeping the electrical efficiency at a satisfactory level.

The biggest problem of the PV panel is decreasing efficiency with increasing temperature of PV cells

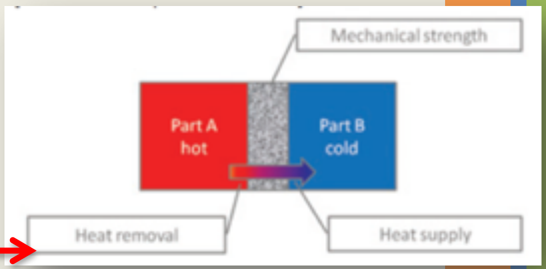


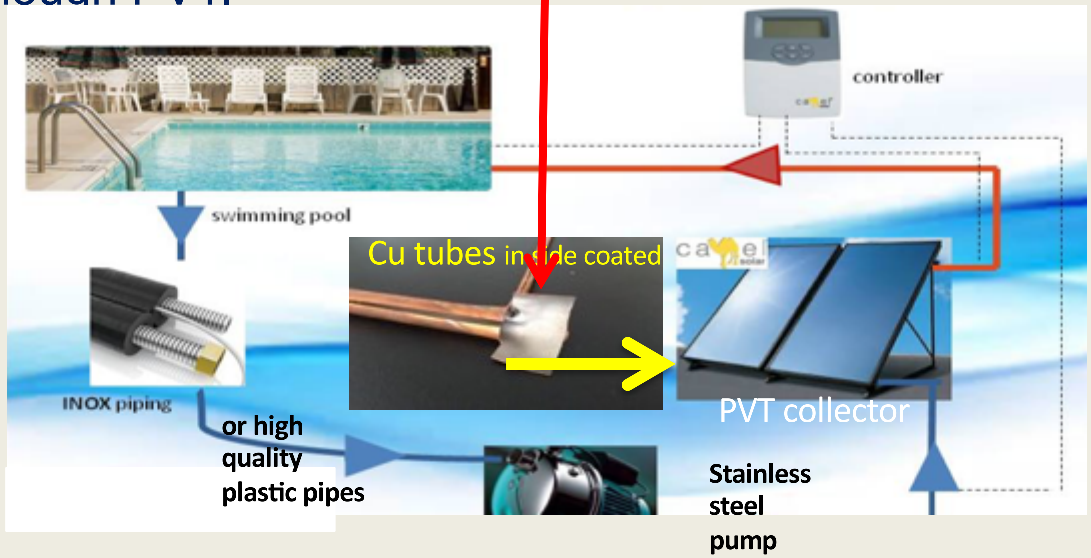
Dependence of power efficiency from temperature of PV panel

PVT collector can be improved through...

Plasma as result of their R&D activities, works toward improving the efficiency of the PVT collector:

1. **Thermo conductive adhesive,** for better heat transfer from back sheet to absorber
2. **Self cleaning,** low soiling (anti dust), and
3. **In side corrosive resistant coating** for direct circulation of chlorinate or see salt swimming pool water though PVT.





Testing of PVT collectors in SPF lab Switzerland

PVT Plasma-Camel unglazed and glazed collectors have the highest efficiency worldwide

Test results of PVT unglazed collector

Measured from SPF Switzerland institute for thermo dynamic

INSTITUT FÜR SOLARTECHNIK

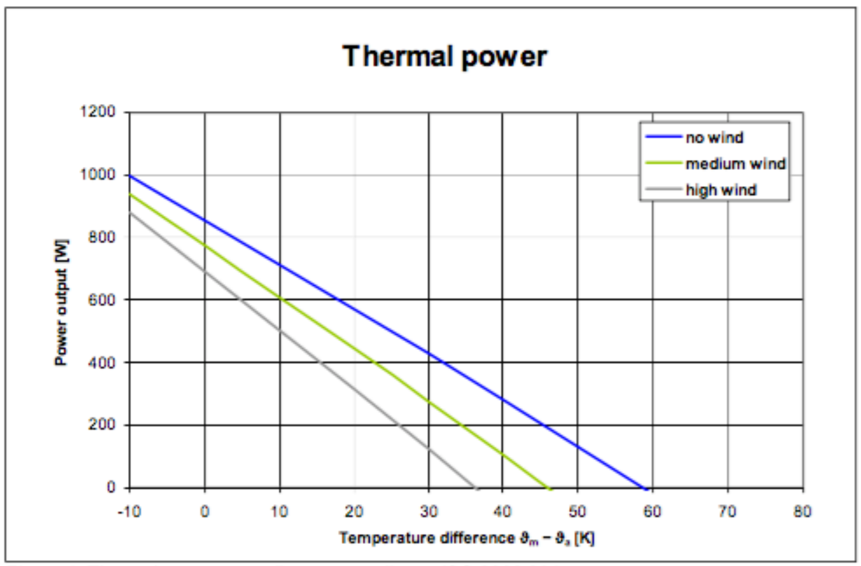


Figure 1: Thermal power per collector according to ISO 9806:2017

INSTITUT FÜR SOLARTECHNIK

Power output per collector unit under SRC
The thermal output under standard reporting conditions (SRC) for the tested collector under Blue Sky conditions is approximated by:

$$\dot{Q} = A_G\left[\left(\eta_{0,\mathrm{hem}} - a_6 u'\right)G - \left(a_1 + a_3 u'\right)\left(\vartheta_m - \vartheta_a\right) - a_2\left(\vartheta_m - \vartheta_a\right)^2 + \left(a_4 - a_7 u'\right)\left(E_L - \sigma T_a^4\right)\right]$$

where u' = u – 3 ms^{-1} and

Climatic conditions	**Blue sky**		
G_b	850 Wm^{-2}		
G_d	150 Wm^{-2}		
$E_L - \sigma \cdot \vartheta_a^4$	−100 Wm^{-2}		
ϑ_a	20 °C		
u	No wind: 0 ms^{-1}	Medium wind: 1.5 ms^{-1}	High wind: 3.0 ms^{-1}

Table 3: Climatic conditions for presenting the performance results according to ISO 9806:2017

$\vartheta_m - \vartheta_a$ [K]	**ϑ_m [°C]**	**u = 0 ms^{-1}**	**u = 1.5 ms^{-1}**	**u = 3.0 ms^{-1}**
-10	10	980	920	860
0	20	845	761	677
10	30	707	598	490
20	40	565	432	300
30	506	420	263	106
40	60	271	90	--
50	70	119	--	--

Table 4: Power output per collector under the indicated wind conditions according to ISO 9806:2017

Maximum measured temperature difference	49 K
Power output data are valid for the maximum temperature difference	80 K
Peak Power per unit	845 W

Test results of PVT glazed collector based of Pikcel 280 Wp PV module Measured from SPF Switzerland institute for thermo dynamic

SPF INSTITUT FÜR SOLARTECHNIK

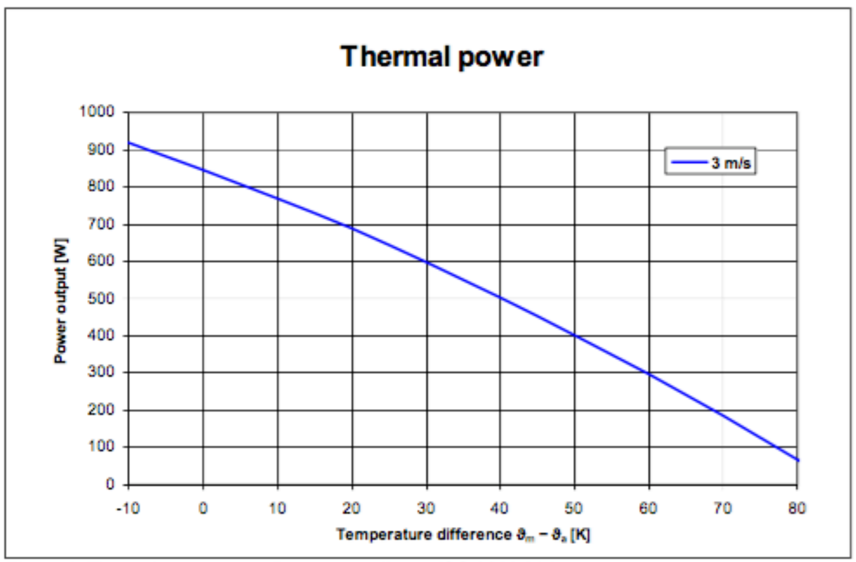


Figure 1: Thermal power per collector according to ISO 9806:2017

SPF INSTITUT FÜR SOLARTECHNIK

Collector on the test rig

Figure 3: Collector on the solar simulator

Test centre Plasma

Test centre Plasma

Two separate equipment's , software's, monitors, for monitoring through internet

Test center has two separate equipment's and software's for measurement's
 and on line monitoring nearly all parameter's of PVT collectors :

Solar radiation, ambient temperature and conditions,
тemperatures in boilers, in let and out let temperatures on PVT, I (Amperes), U (Volts) and power out put (W) from every PVT, in side and out side refrigerant pressure and temperature .

Test centre

Out side installed PVT collectors with different circulating fluids

Inside installed boilers, pumps stations, heat pumps,

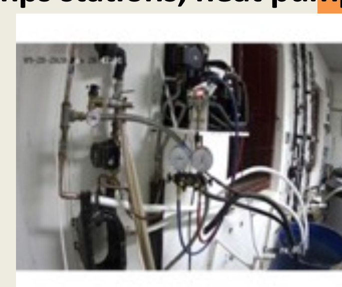
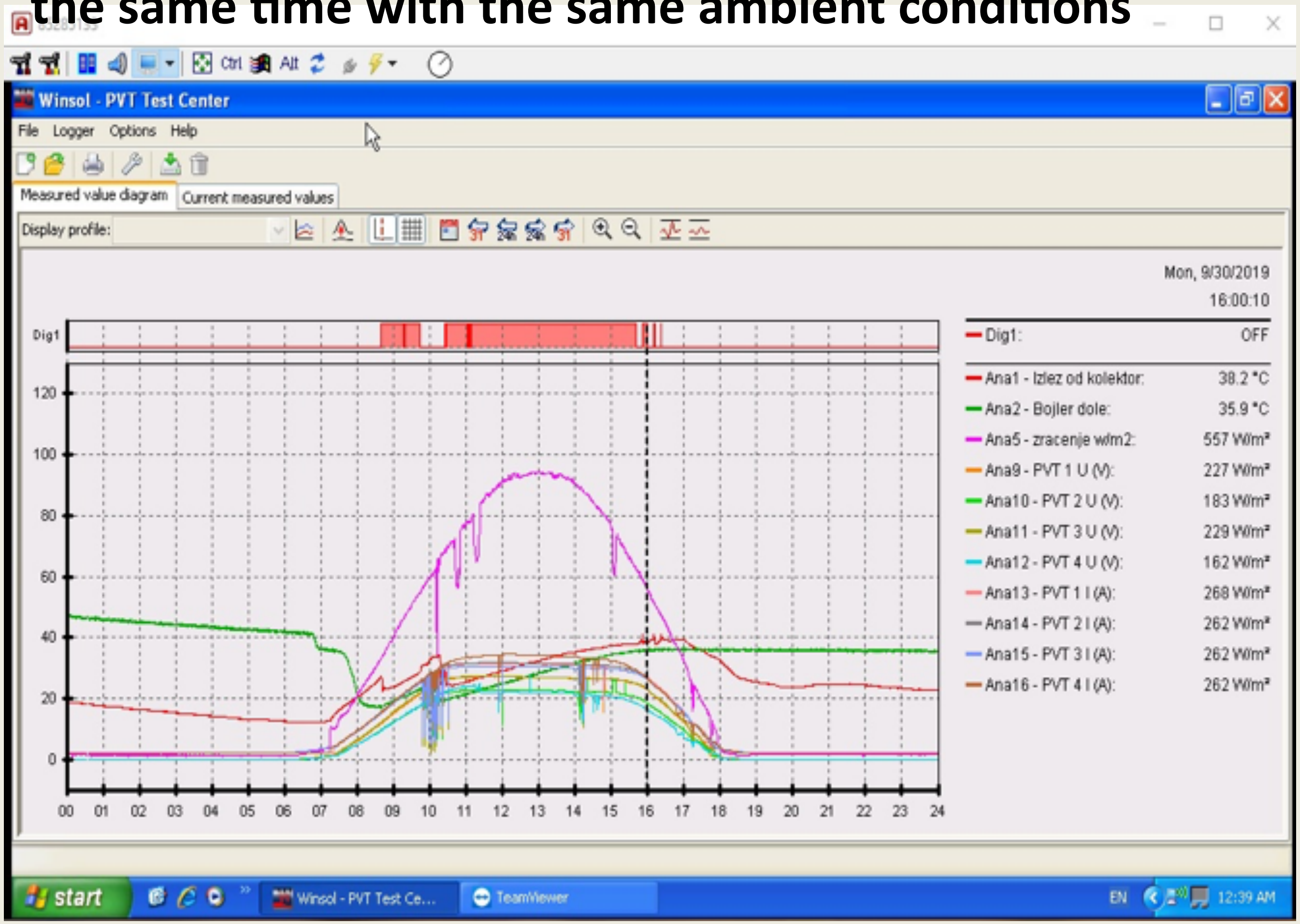


Diagram of PVT systems measurement's for four independent PVT systems in the same time with the same ambient conditions



Solar radiation, ambient temperature and ambient conditions,

Temperatures in boilers, in let and out let temperatures on PVT i.e. produced heat per PVT

Power out put in Watts, per every PVT and dependence from temperature of PV cells

1 Euro / day = 1 ton hot water /day (t =55^0C)

North Macedonian weather condition of 5 October 2020

PVT (refrigerant) assisted HP

Power output / h during morning
4 x PVT x 280Wp= 1 kwh el +3,2 kWh thermal
Total, power out put = 3.2 kWh +1 kWh el = **4.2 kWh**
Total el. consumption from heat pump = **0.82 kWh**
COP morning = 4.2/0.82 ≈ **5.12**

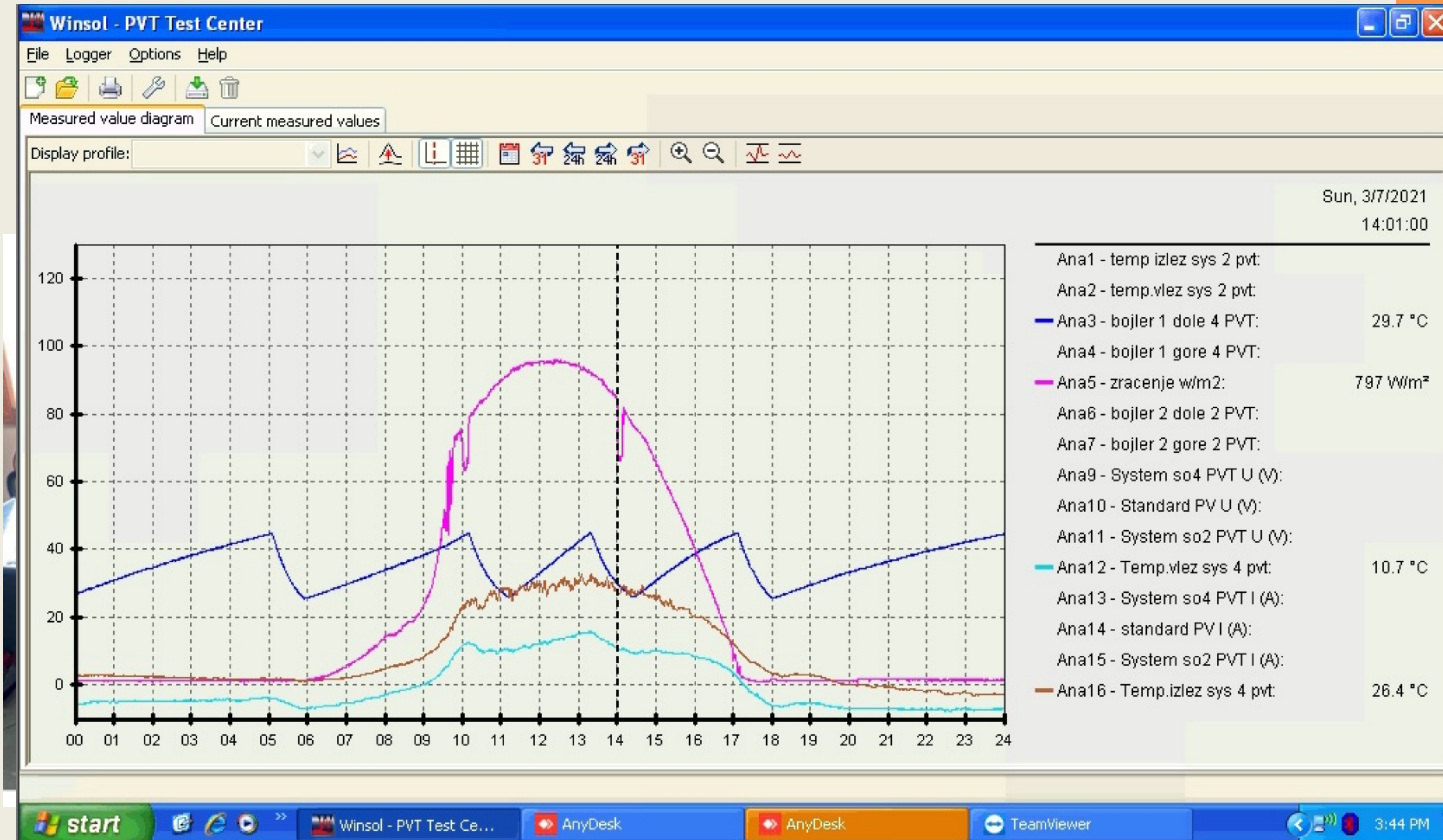
COP noon =
3.9 kWh + 1 kWh el = 4.9 kWh
el. consumption= 0.89 kWh
COP noon 4.9 kWh / 0.89 kWh =
COP noon = 5.5

COP night
 2.65 kWh = 2.65 kWh
el. consumption= 0.65 kWh
COP night= 2.65 kWh / 0.73 kWh =
COP night = 3.63

Total power out put /day = 40kWh th + 4kWh el =
44 kWh = 1 ton hot water on 55^0C
El. consumption= 14kWh
1 kWh = 0.07 Eur

14 kWh x 0.07 Eur/kWh = 0.98 Eur

Current Plasma experience with direct circulation of Refrigerant through HP compressor 0.45 kW and 2 PVT collectors



14 kWh x 0.07 Eur/kWh = 0.98 Eur

PVT installed systems

- case studies

PVT combined system for swimming pool heating and for preheated water for sanitary needs and space heating

Location: North Macedonia, Skopje
Number of PVT =16
Surface / PVT =1.6 m2
150 W/m2 Pic El. power
490 W/m2 Pic Th. power
Power out put / 14 PVT:
58 kWh heat /day and
16 kWh el power / day
Swimming pool : 75 m^3 plus small swimming pool 6 m^3
Benefit from PVT system:
During the summer period , temperature of the swimming pool water is **31 ^{0}C + - 1 ^{0}C**

PVT system at Football Federation building

Location: Skopje, North Macedonia
Number of PVT =32
Surface of PVT =1.6 m2 / PVT
150 W/m2 Pic El. power
490 W/m2 Pic Th. Power
Storage : 3 ton
Thermal power out put = 85 kWh/day
El. power out put = 30 kWh/day

PVT combined system for swimming pool heating and for sanitary water

Location: Skopje, North Macedonia
Number of PVT =14
Surface of PVT =1.6 m2/PVT
150 W/m2 El. power
490 W/m2 Th. Power

PVT thermo siphon type installed on private building with four apartment's

PVT system with 32 PVT collectors and four solar thermal collectors for space and swimming pool heating

Municipality Karpos

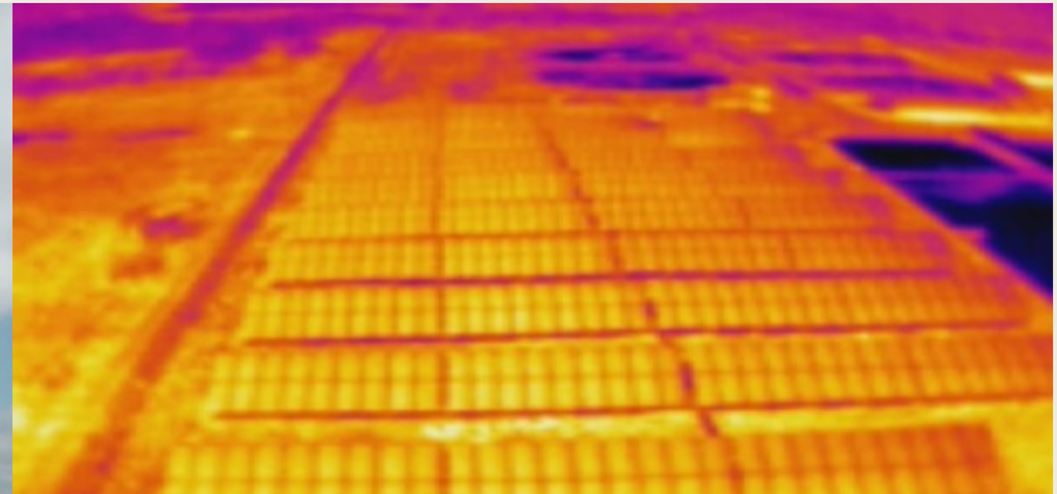
Kinder garden 3.2.kW PVT system

Instaled 80 PVT collectors in Warsou Poland in public building

Installed PVT thermosyfon system in Dubai in front of hotel Burj Al Arab as prototyp

Camel Solar demo center Dubai

Instaled   PVT thermo syfon system in Bulgaria ,
children garden Sofia



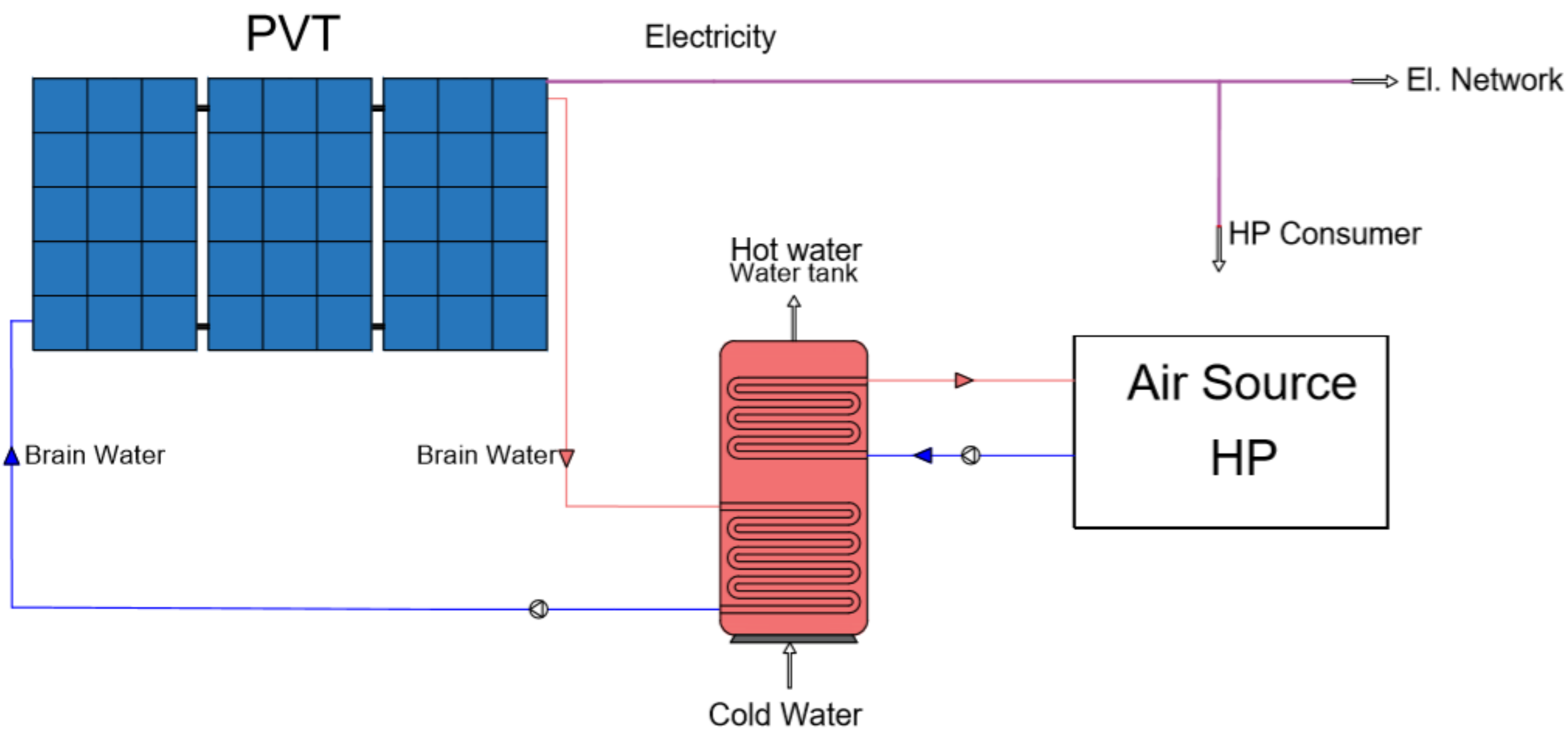
News: PVT installations from Camel Solar as member of EU H2020 project ENSNARE-Nearly zero energy building

Demo building 1: Tartu *(Estonia)*	**Demo building 2: Sofia** *(Bulgaria)*	**Demo building 3: S. Demetrio** *(Italy)*
		
Façade 442m^2, 26 windows, 10 dwellings	Façade 471m^2, 42 windows, 6 dwellings, 80-100 kWh/m^2 year	Façade 942m^2, 58 windows, 7 dwellings, 180-200 kWh/m^2 year
Virtual Demo 1: Glasgow *(UK)*	**Virtual Demo 3: Amsterdam** *(NL)*	**Virtual Demo 3: Milano** *(Italy)*
		
Façade 980m^2, 100 windows,	Office Building to be renovated as residential.700m^2, 80% glazed	Façade 3100m^2, 144,91 kWh /m^2 year

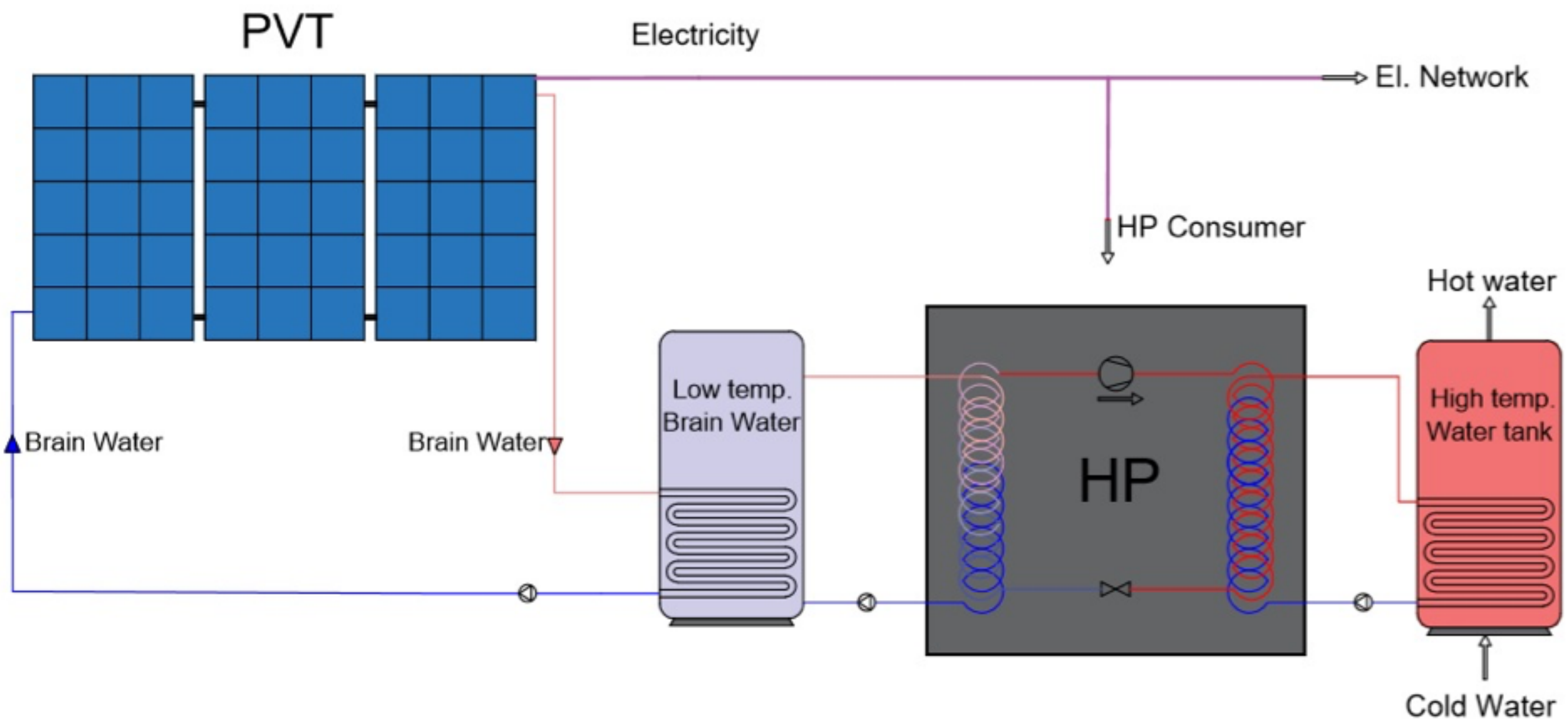
Future trends related to PVT systems

NOTE: In shematics is one gramatic mistake: brain water instead brine water

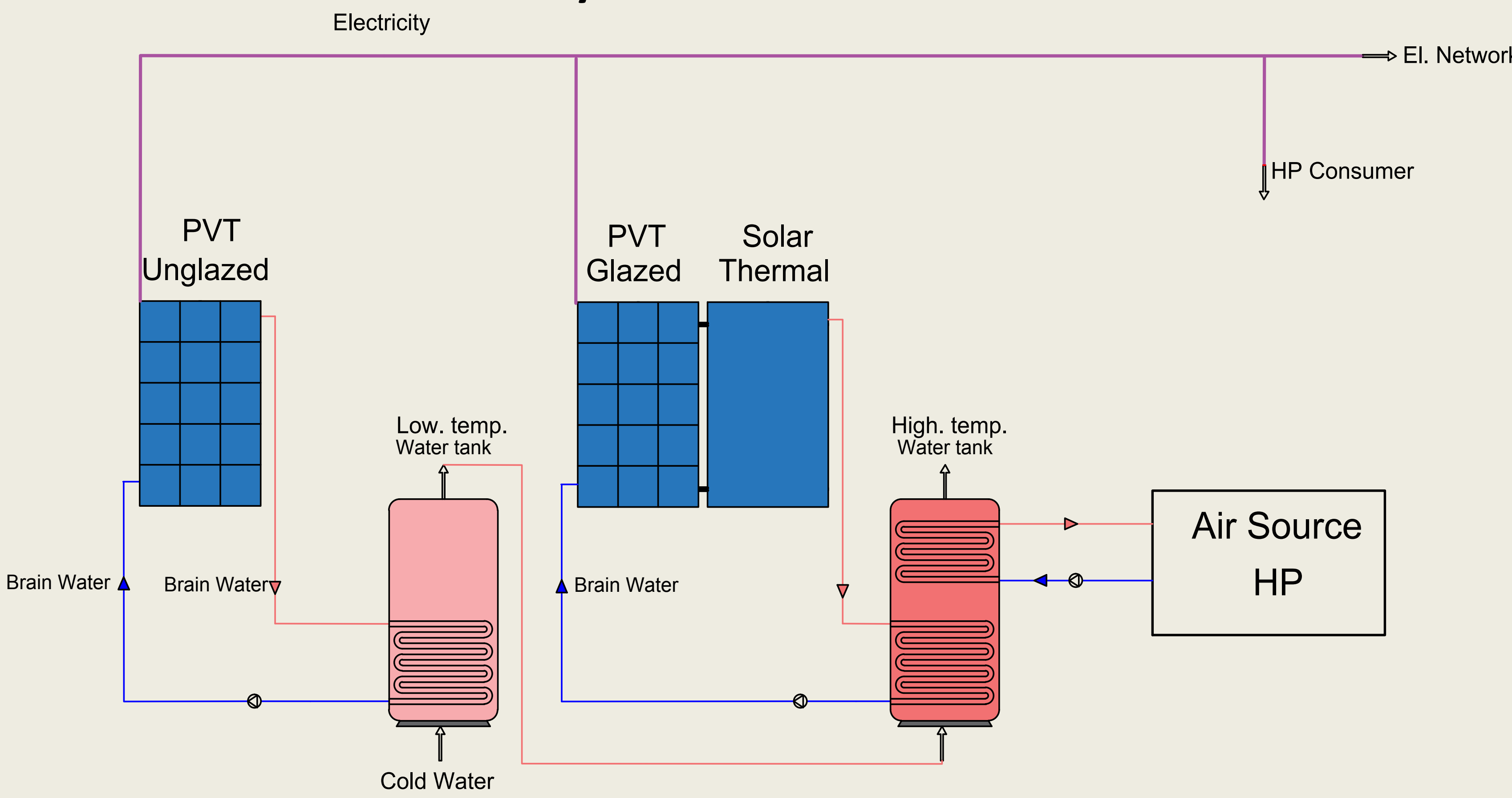
Standard PVT assisted HP



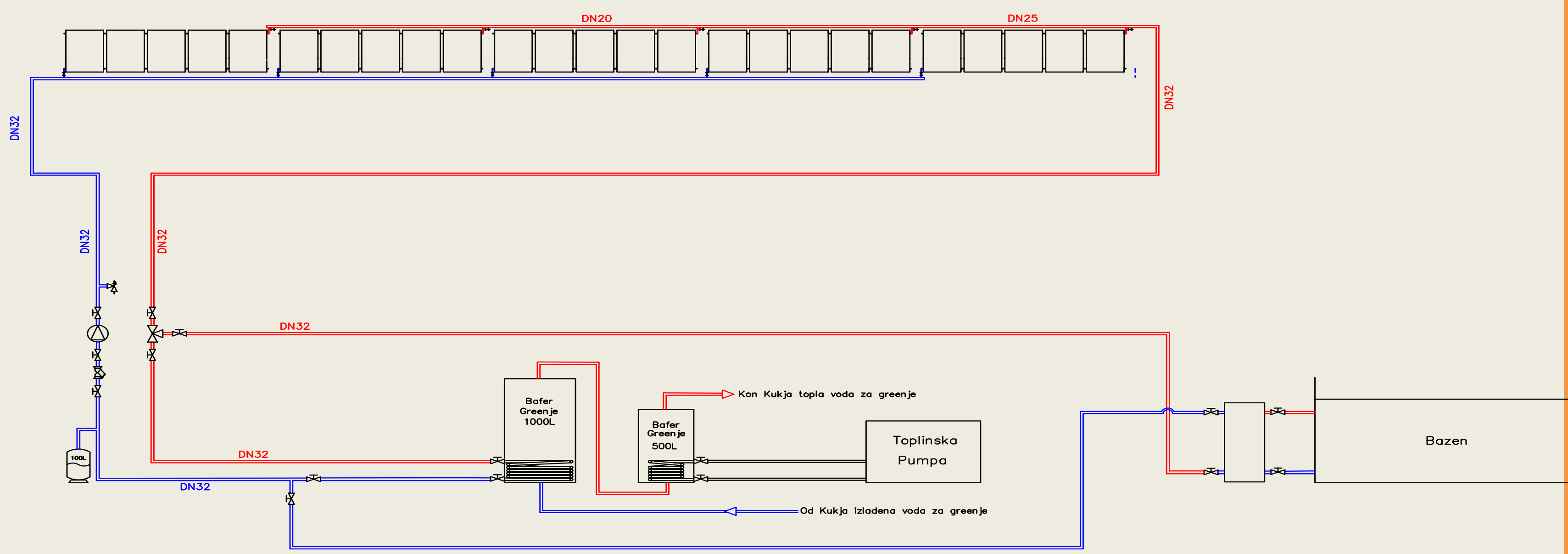
PVT assisted HP with direct circulation of brain water through low temp. storage



Combined PVT system with Solar thermal collectors and HP



PVT system for heating of out side swimming pool during the summer and Sanitary and space heating during the winter period heating



The future of solar energy utilization is production of electrical and thermal energy at the same time from the same PVT device and combined PVT assisted HP systems

PVT video

https://www.youtube.com/watch?v=HMFFkIj6uo0