DESIGN PROCEDURES

Design procedure

- On-site inspection and data gathering
- Calculation of absorber area
- Calculation of storage volume
- Collector connection
- (anti freezing protection)
- Circuit pressures
- Pressure drops in the hydraulic circuit
- Expansion vessel

On-site inspection التفتيش الموقعي

- Always check:
- Roof: الأسطُح
  - Condition of the roof حاله السطح
  - Access possibilities امكانيه الوُصُول
  - Available area المساحه المُتوفره
  - Orientation and shadow problmes التوجيه و عائق الظل

- Does the storage tank fit in the building? (room dimensions, door dimension, stairs dimension…)

Design process

- On-site inspection
- Calculation/estimation of DHW needs
- Choice of most suitable system type
- Dimensioning of collector surface and storage volume
  - **** end of design process for small plants ****
- For large scale plants:
- Dimensioning of heat exchanger(s)
- Dimensioning of solar loop (pumps, pipes, valves, expansion vessel)

Hot water need

1. Energy bill evaluation
    - Do not use energy bills from vacation periods
2. Estimation
    - For domestic applications: 30 – 60 l/person per day at 45 °C

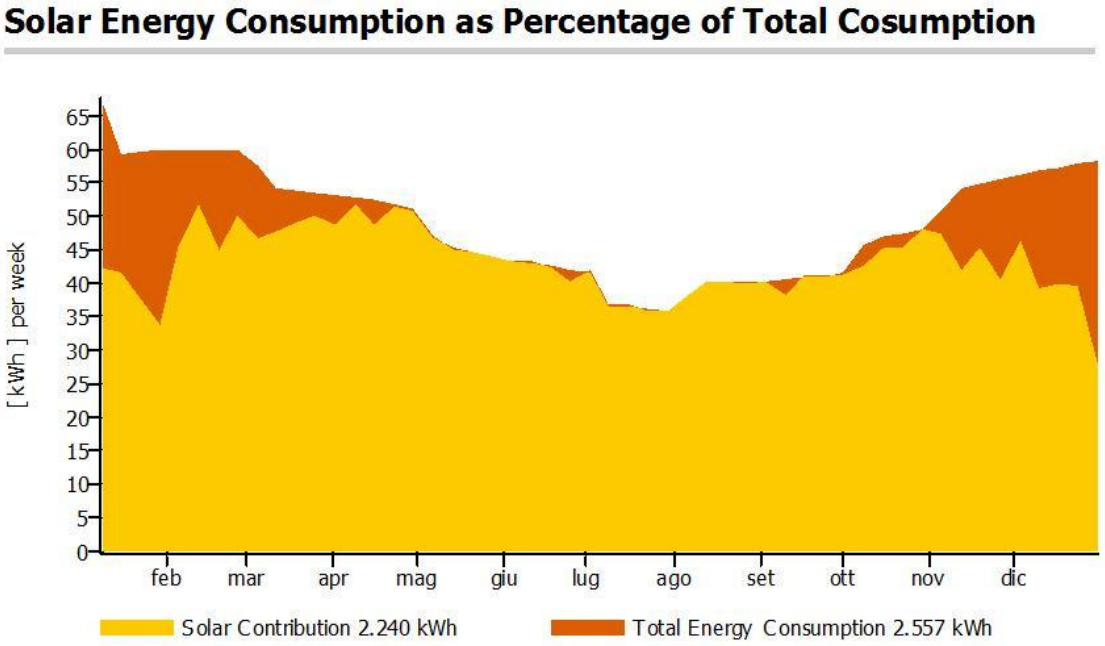
Hot water need

- hand washing: 3 l/p*day
- shower: 50 l/p*day
- bath: 150 l/p*day
- hair washing: 10 l/p*day
- dish washing: 20 l/day

ثقافة الطاقة الشمسية هي ثقافة توفير وليست ثقافة تبذير.

Design rules of thumb– small residential systems optimal dimensioning

- Number of persons: 5
- Daily consumption: 40 l/p
- Hot water temperature: 45 °C
- Cold water temperature: 12 – 18 °C
- Storage tank volume: 70 l/m^2



Design rules of thumb – small residential systems optimal dimensioning

City	Absorber area every 40 l/day [m2]	Solar fraction [%]	Solar energy [kWh/m^2 a]
Cairo	0,6	89	760
	0,4	79	1.015
Alexandria	0,6	90	765
	0,4	80	1.020
Hurghada	0,6	95	815
	0,4	87	1.130
Sohag	0,6	95	815
	0,4	88	1.135
Kosseir	0,6	97	830
	0,4	91	1.175
Assuan	0,6	98	840
	0,4	93	1.195

- Calculations were made using a medium quality flat plate collector. Figures may decrease a lot when using low quality products, or increase when using high quality evacuated tube collectors.

Design rules of thumb– small residential systems highest solar fraction

City	Collector area every 40 l/day [m2]	Solar fraction [%]	Solar energy [kWh/m^2 a]
Cairo	1	94	485
Alexandria	1	95	488
Hurghada	1	98	506
Sohag	0,8	97	625
Kosseir	0,8	98	639
Assuan	0,8	99	640

Calculations were made using a medium quality flat plate collector. Figures may decrease a lot when using low quality products, or increase when using high quality evacuated tube collectors.

Design rules of thumb– large systems for hotels optimal dimensioning

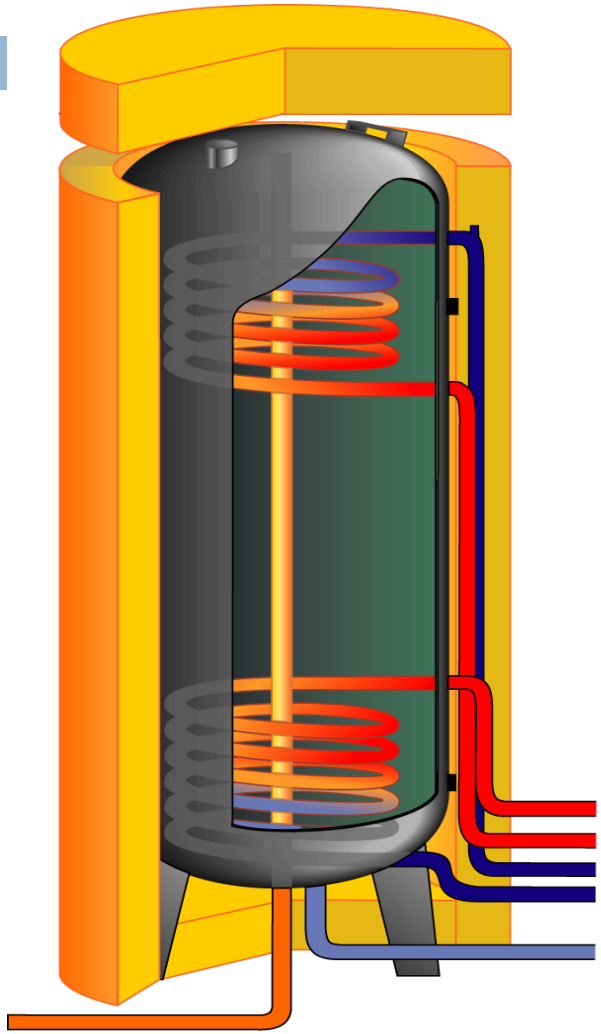
City	Collector area every 50 l/day [m2]	Solar fraction [%]	Solar energy [kWh/m^2 a]
Cairo	0,6	92	1.039
	0,5	87	1.156
Alexandria	0,6	93	1.049
	0,5	88	1.227
Hurghada	0,5	93	1.253
	0,4	85	1.406
Sohag	0,5	93	1.259
	0,4	86	1.418
Kosseir	0,5	95	1.284
	0,4	88	1.447
Assuan	0,5	96	1.311
	0,4	90	1.495

Calculations were made using a medium quality flat plate collector. Figures may decrease a lot when using low quality products, or increase when using high quality evacuated tube collectors.

Design rules of thumb– correction factors

	West						East
	90	60	30	0	-30	-60	-90
0	92	92	92	92	92	92	92
10	91	94	96	97	96	94	91
20	89	94	98	99,6	98	94	89
25	87	94	98	100	98	94	87
30	85	93	98	99,7	98	93	85
90	51	57	58	56	58	57	51

Dimensioning of storage tank



Ready-to-use water

20 l/p

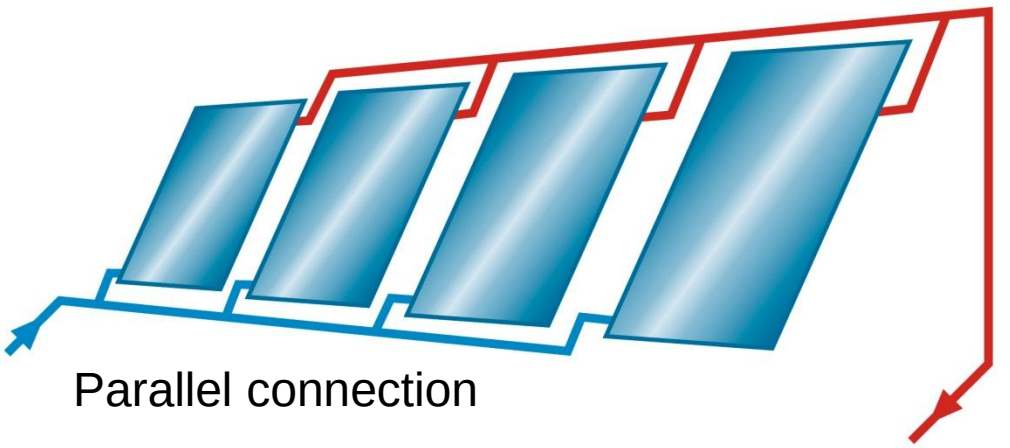
Storage volume: 70 l/m^2 (flat plate collectors)
90 l/m^2 (vacuum tube collectors)

Source: Ambiente Italia/Wagner

Collector connection

Parallel connection:

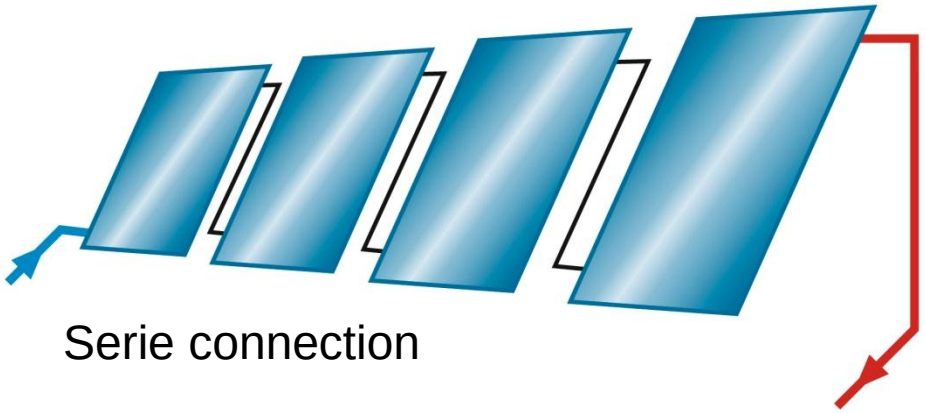
Flow rate is devided through each collector, temperature increase is the same. If necessary: inverse conection to avoid flow rate diffenrences.



Parallel connection

Serie connection:

Flow rate is the same through each collector, temperature increase raises from one collector to the other. Too high temperatures lead to low efficiency.

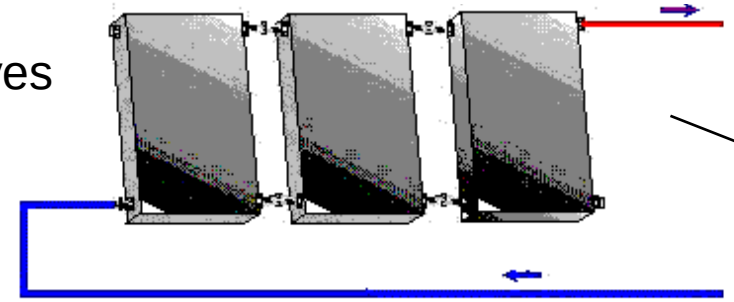


Serie connection

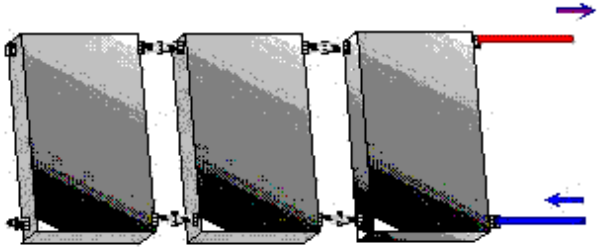
Collector connection

Up to 3 - 6 collectors

yes

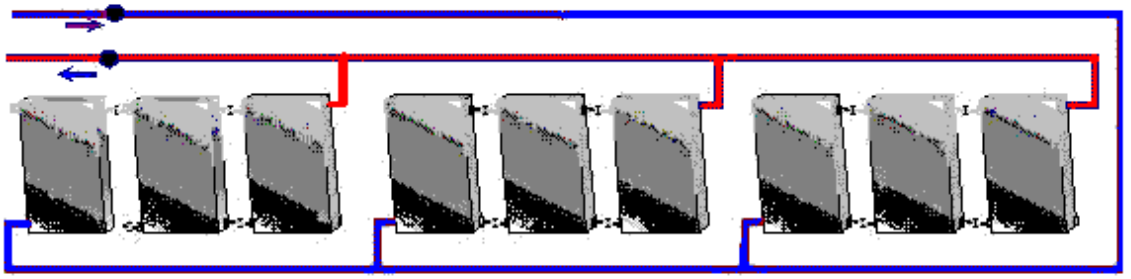


no



Maximum number of collettors to be connected in serie: 3 to 6 (depending on the model)

More than 3 - 6 collectors



Delta T across che solar field should not exceed 10 – 20 °C.

Pressures in a solar loop

	recommended
p_I (initial) = $p_{water\ column}$ + 0,5	2 bar up to 15 m
p_{EV} (expansion vessel precharge) = p_I - ca. 0,5 bar	1,5 bar
p_F (final) = 5 bar (no more than 5,5 bar)	5 bar
p_{SV} (security valve) = p_F + 1 bar	6 bar

Pipes and pumps

- Pipes

Flow rate (l/h)	External diameter x thickness
< 240	15 x 1
240 - 410	18 x 1
410 – 570	22 x 1
570 – 880	28 x 1,5
880 - 1450	35 x 1,5

- Pump: up to 12 m^2 collectors the smallest available heating pump with three speeds is usually suitable (es. Grundfos UPS 25-40)

Expansion vessel

Correct dimensioning of expansion vessel is crucial for the proper operation of a solar thermal system!

Stagnation must be considered!

Dimensionamento del vaso di espansione:

contenuto del circuito $V_{FL} = V_C$ (collettore) + V_T (tubi) +

+ V_{SC} (scambiatore di calore) + V_A (altri componenti)

espansione termica $\Delta V_{FL} = e \times V_{FL}$ (e = 0,045 acqua, 0,07 miscela)

- volume utile $V_U = (\Delta V_{FL} + V_C) \times 1,1$ (indice di sicurezza)

- volume nominale $V_N = V_U \times (p_F + 1)/(p_F - p_I)$

Valori di riferimento per piccoli impianti:

Superficie Collettore [m^2]	Pressione iniziale p_I = 1,5 bar	p_I = 2,5 bar
5	12 l	12 l
7,5	18 l	25 l
10	25 l	35 l
15	35 l	50 l