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Building Integration of Solar Thermal Systems – TU1205 – BISTS

Solar Combi systems

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Faculty of Power and Aeronautical Engineering, MEiL
Warsaw University of Technology, PW

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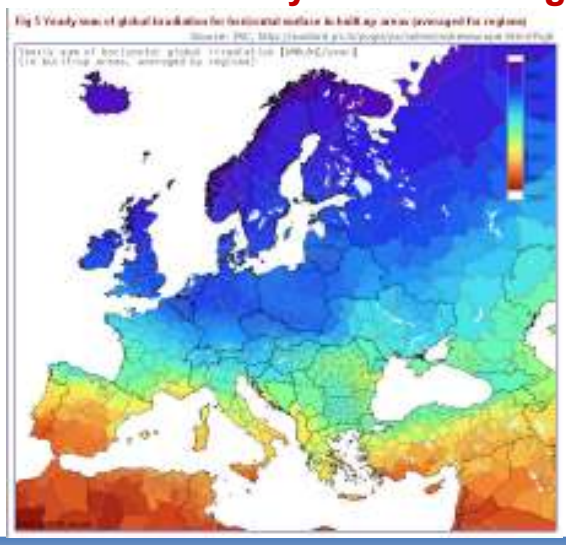
Availability of solar energy



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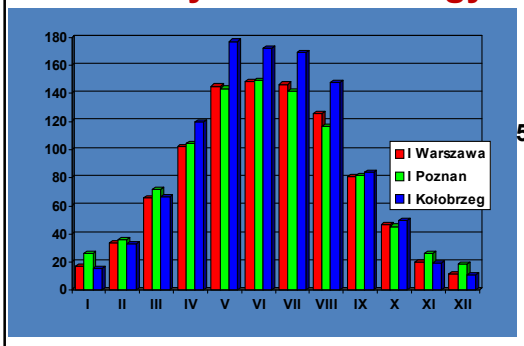
Availability of solar energy



54,5⁰

49⁰

Monthly solar irradiation on horizontal surface

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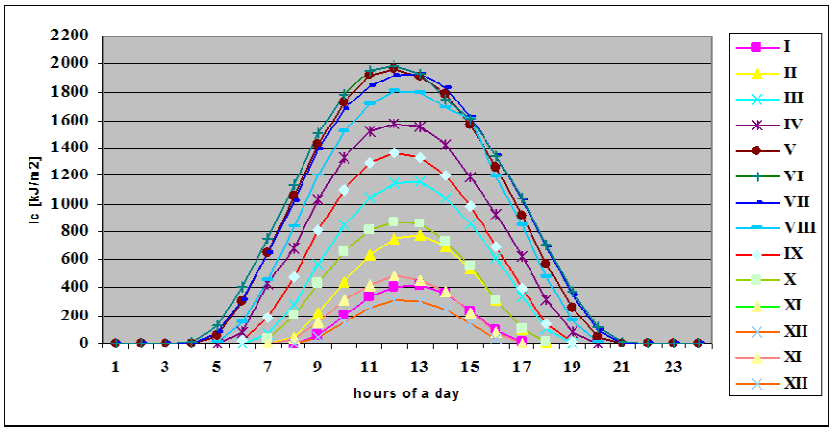
Availability of solar energy



Daily solar irradiation on horizontal surface

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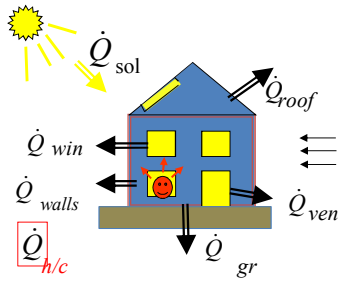

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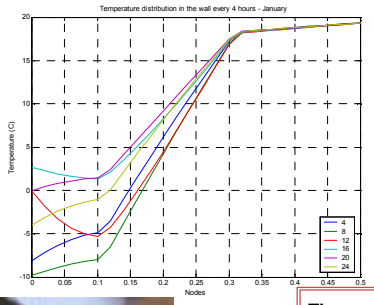
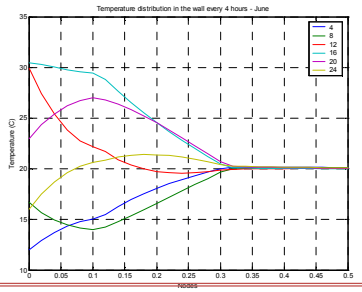
Temperature distribution inside external vertical wall at averaged day in January June





Thermal and physical parameters of wall layers

Layer	Material	Thickness	Specific heat	Density	Thermal conductivity
From outside		δ [m]	c [kJ/kgK]	ρ [kg/m³]	λ [W/m K]
1	Mineral wool	0,20	0.70	24	0.038
2	Brick	0,25	0.84	1600	0.76

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Averaged heat transfer coefficients for different elements of a building envelope in the EU countries

	2005 - U [W/(m²K)]	2030 - U [W/(m²K)]
External walls	0.65	0.23
Roof	0.87	0.1
Floor on a ground	0.3	0.21
Windows	2.75	1.4

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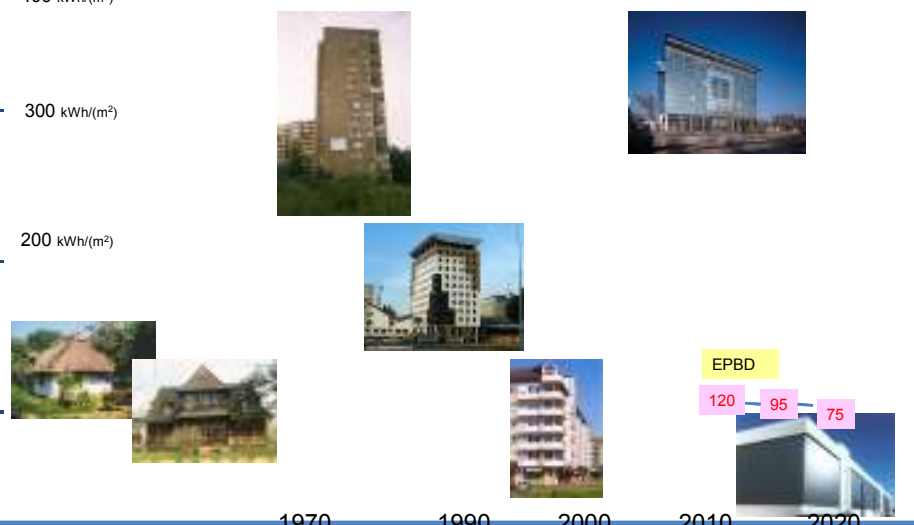
Annual primary energy intensity index Ep_{heat} [kWh/(m²) year]



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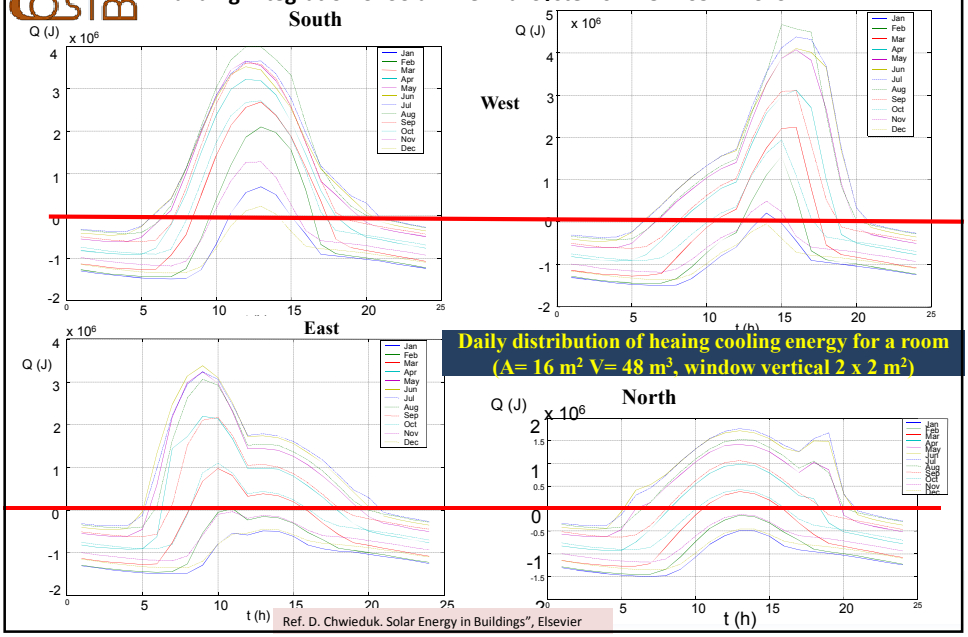

Daily distribution of heaing cooling energy for a room (A= 16 m² V= 48 m³, window vertical 2 x 2 m²)

Ref. D. Chwieduk. Solar Energy in Buildings", Elsevier

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Monthly heating/cooling energy demand and energy losses/gains through envelope of south rooms, A= 16 m² V= 48 m³, with vertical external walls and big windows (2 x 2 m²)

[MJ]	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year Q_h	Year Q_c
$Q_{h/c}$	-637,41	-276,77	8,90	360,68	642,61	701,58	795,66	821,12	558,98	188,55	-331,92	-638,09	-1884,19	4078,08
Q_{wall}	-63,90	-52,19	-45,96	-23,18	-4,32	3,66	8,89	7,42	-5,27	-26,09	-44,12	-57,26	-322,29	19,97
Q_{win}	-404,82	-78,06	189,8	468,61	691,44	716,68	793,23	826,62	606,62	300,06	-169,71	-432,97	-1085,56	4593,06

Monthly heating/cooling energy demand and energy losses/gains through envelope of south rooms, A= 16 m² V= 48 m³, with vertical external walls and small windows (1 x 1 m²)

[MJ]	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year Q_h	Year Q_c
$Q_{h/c}$	-368,45	-253,42	-171,28	-19,83	101,86	146,87	185,02	183,45	83,45	-63,00	-231,34	-342,39	-1449,71	700,65
Q_{wall}	-95,85	-78,28	-68,93	-34,77	-6,48	5,49	13,33	11,12	-7,90	-39,13	-66,17	-85,89	-483,4	29,94
Q_{win}	-103,92	-28,62	32,60	99,69	152,84	160,14	178,15	185,25	133,7	61,56	-47,08	-108,64	-288,26	1003,96

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Diversification of thermal solar systems
Solar combi systems - space heating & DHW

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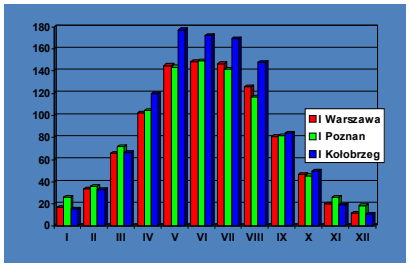

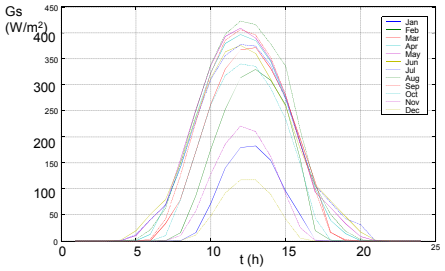

- The intermittent nature of solar radiation and its periodical availability means that storage of solar energy is necessary.
- There are significant daily and especially yearly variations of solar irradiance.
- Most energy needs and especially heating needs are also time dependent.
- Storage is crucial for efficient operation of different types of solar thermal systems, especially for space heating.

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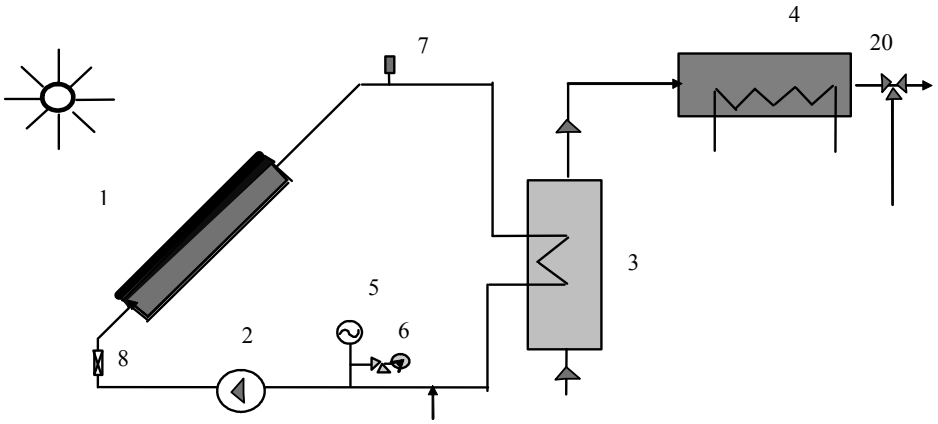
Standard solar DHW heating system



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The general energy balance of storage

Q_u - useful heat rate, W

Q_L – heat loss rate, W

Q_h – heat demand, W

$$Vc_p\rho\frac{dT_s}{dt} = Q_u(t) - Q_L(t) + Q_h(t)$$

$$(Vc_p\rho)\Delta T_s = (Vc_p\rho)(T_{s0} - T_{s1}) = \dot{Q}_u\Delta t - \dot{Q}_l\Delta t - \dot{Q}_h\Delta t$$

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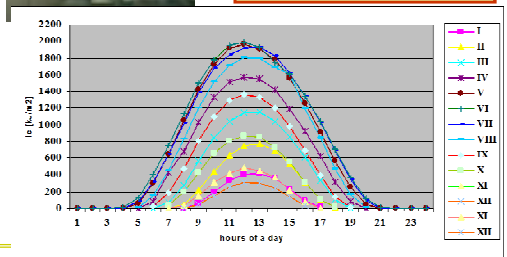
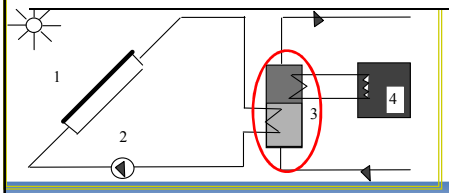
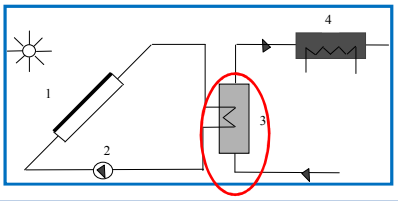
Domestic Hot Water (DHW) systems

350 - 550 kWh/m²year







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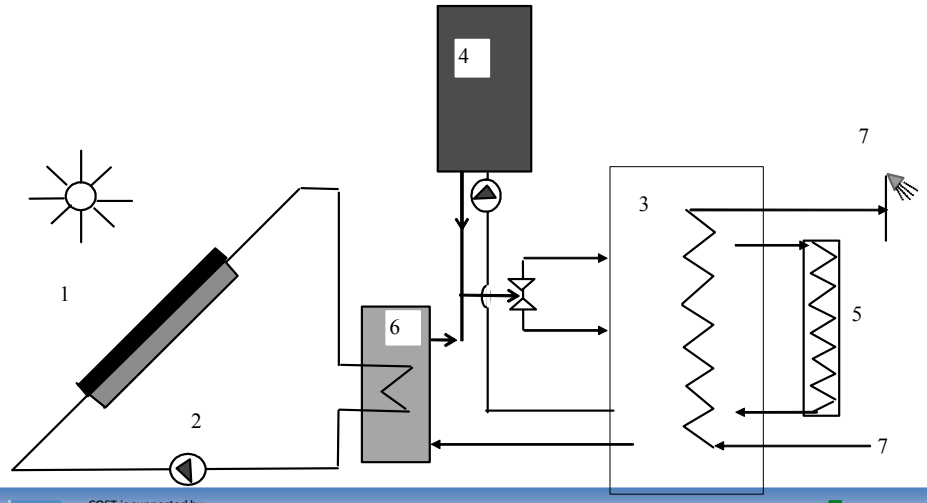
Standard solar COMBI system for DHW and space heating



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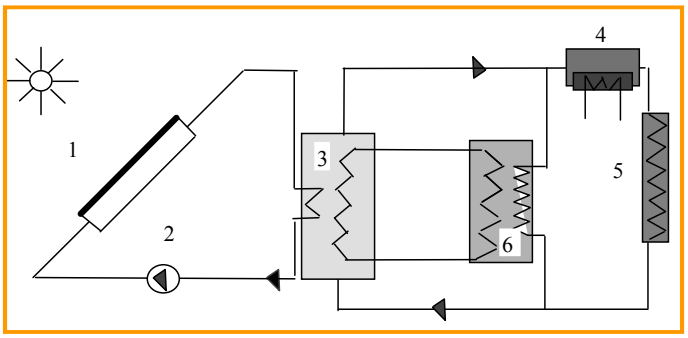
Standard solar COMBI system for DHW and space heating

Solar combi systems are installed mainly in Europe Austria, Germany, Switzerland, The Netherlands, France and in Asia - Japan



450 – 550 kWh/kW$_{th}$

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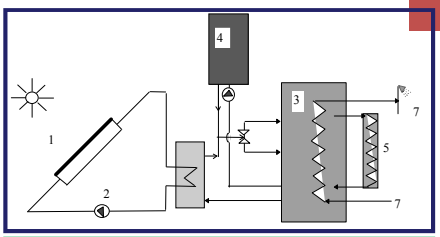
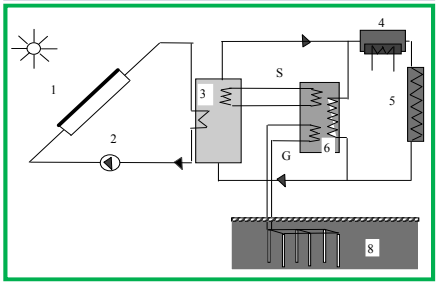
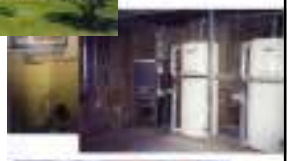
Solar combi systems - space heating & DHW

Solar hybrid systems







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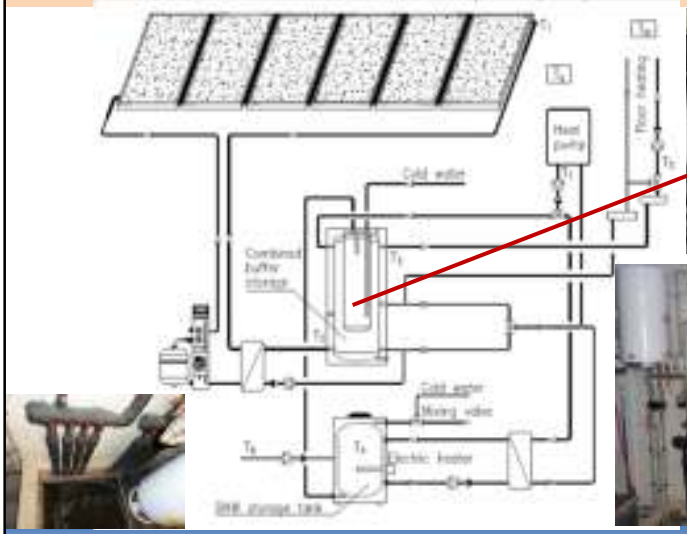
Domestic Hot Water (DHW) + space heating



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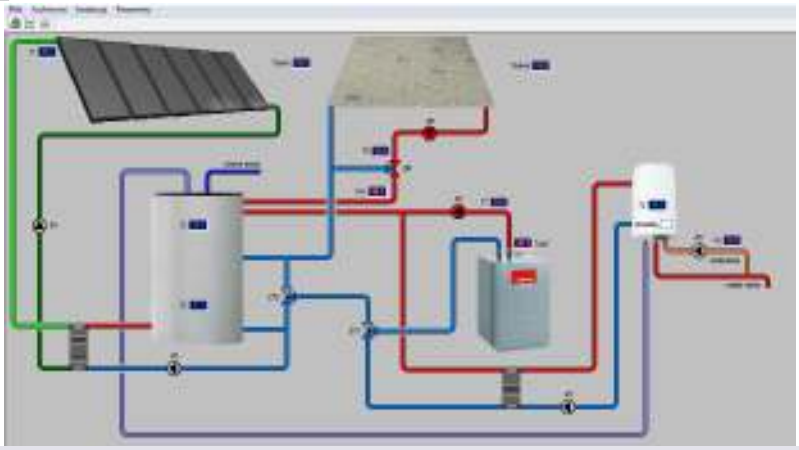

Printscreen from software visualizing operation of a solar heating system cooperating with a ground heat pump in January in a single family house, in Warsaw

Ref. D. Chwieduk. Solar Energy in Buildings", Elsevier

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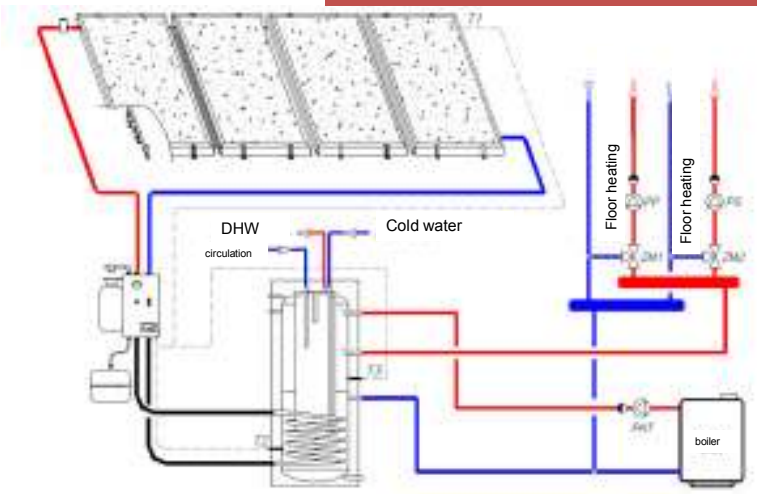
Solar combi systems - space heating & DHW

Solar hybrid systems



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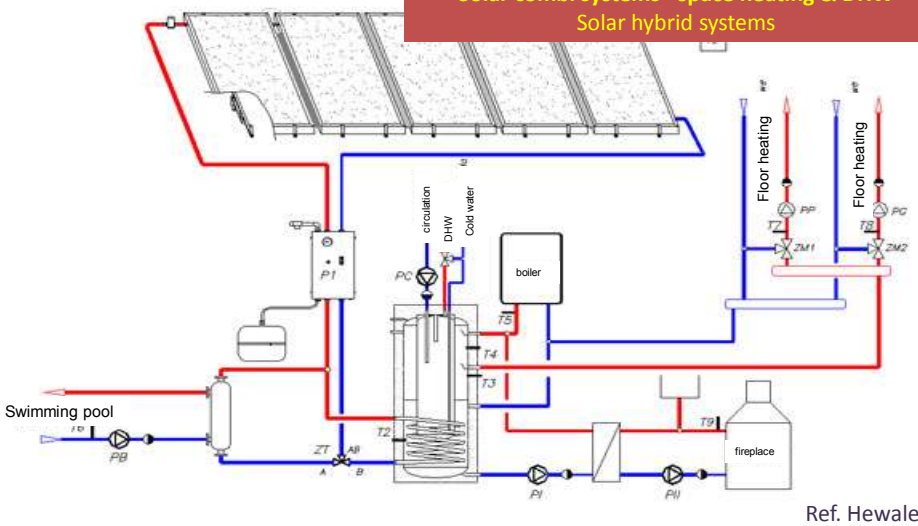
Solar combi systems - space heating & DHW
Solar hybrid systems



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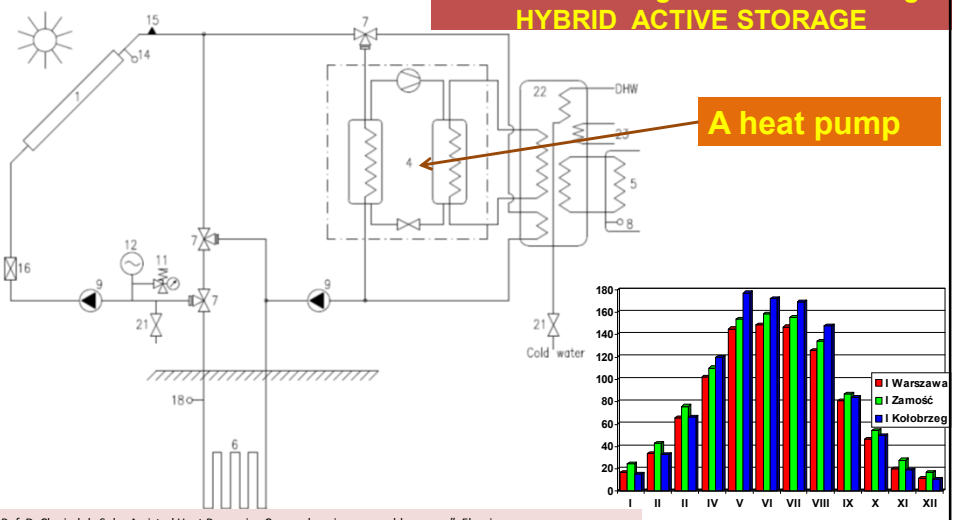
Short term storage + seasonal storage
HYBRID ACTIVE STORAGE



Ref. D. Chwieduk. Solar Assisted Heat Pumps in „Comprehensive renewable energy", Elsevier

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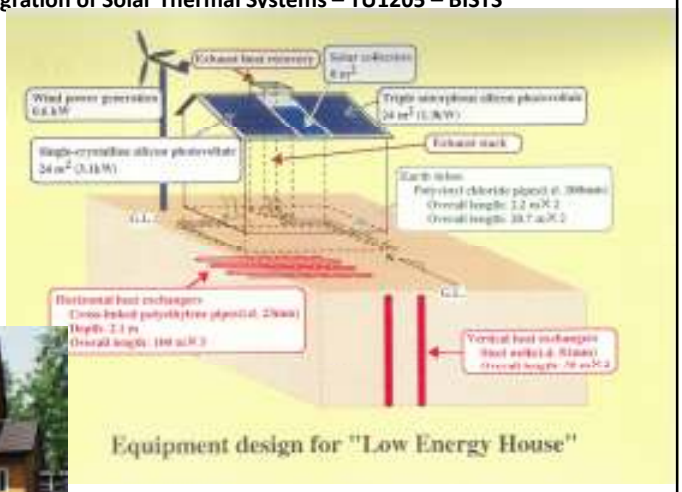

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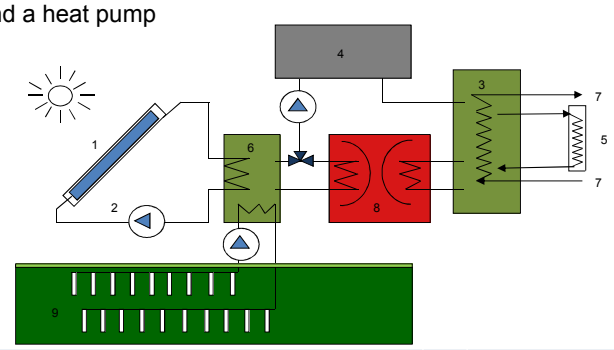
Conceptual diagram of a solar heating system with a seasonal ground heat storage and a heat pump



1	solar collector	5	space heating system
2	circulation pump	6	heat exchangers
3	storage tank with heat exchanger	7	hot tap water system
4	peak conventional heater, e.g. boiler	8	heat pump
		9	ground heat exchanger

Ref. D. Chwieduk. Solar Energy in Buildings", Elsevier

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Solar combi systems - space heating & DHW + storage

Neckarslum, Germany, CSHPSS, 1999, **solar collectors– 5044 m²**, **63400 m³ ground storage**, annual energy consumption 1,7 GWh

Ref. AAE – Intec Austria - Werner Weiss

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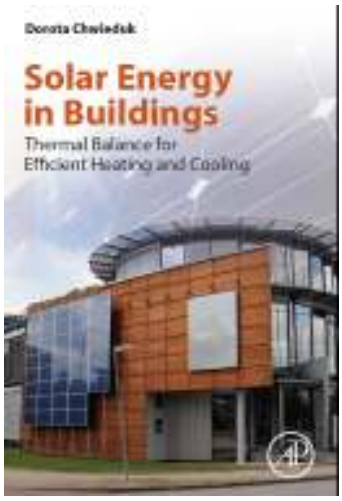

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