SECCA
Sustainable Energy Connectivity in Central Asia

Funded by the European Union

Training workshop "Studying international practices in implementation of innovative energy efficiency technologies in the electric power industry. Methodology, goal and objectives of electricity and heat consumers energy survey"

SEIT building, 62 Bayram Khan st, Mary, 13-19 March 2024

Integrating renewable energy into sustainable buildings

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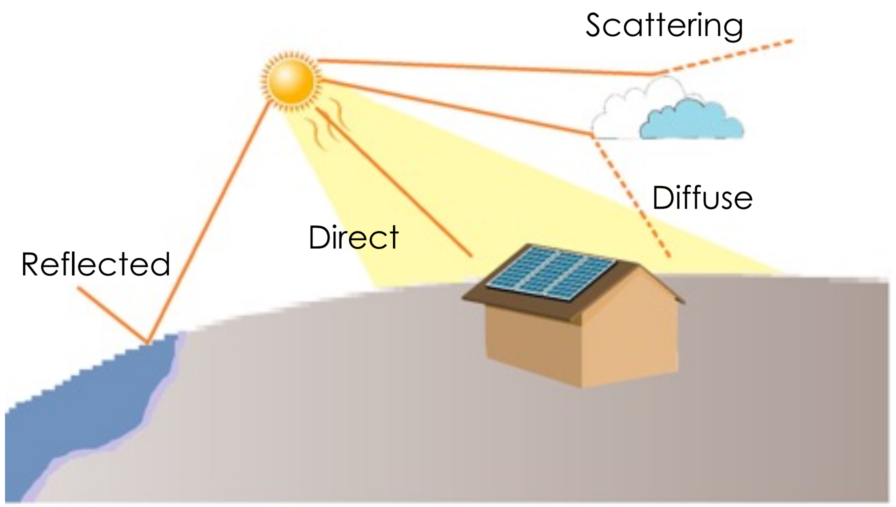
International Consultant, SECCA

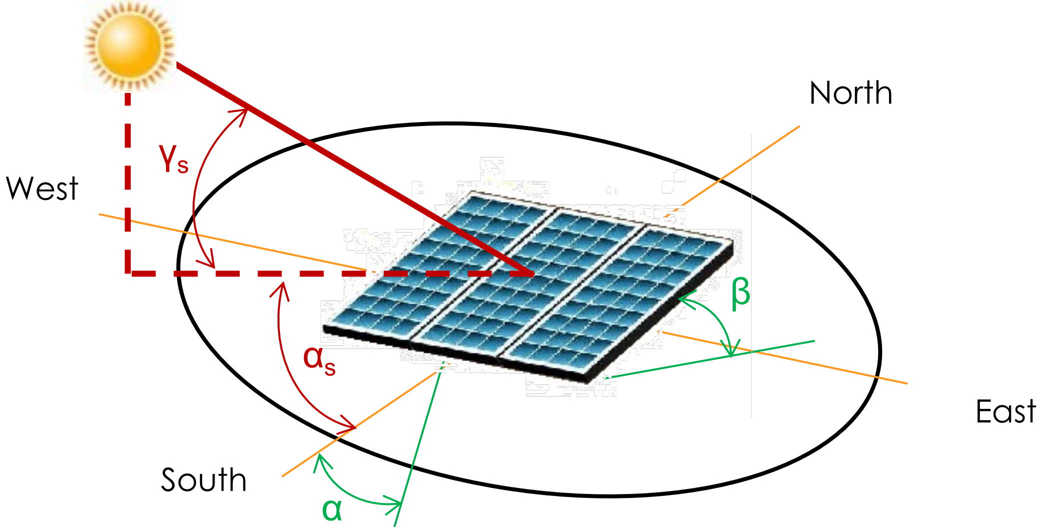
Stantec | intec | ACTED | European University Institute | Robert Schuman Centre for Advanced Studies | FSR Energy Florence School of Regulation

Content

1. Solar thermal systems
2. Solar PV systems
3. Heat pumps

Solar energy





Yearly sum of global irradiation on the horizontal surface, kWh/m² year

Source: http://re.jrc.ec.europa.eu/

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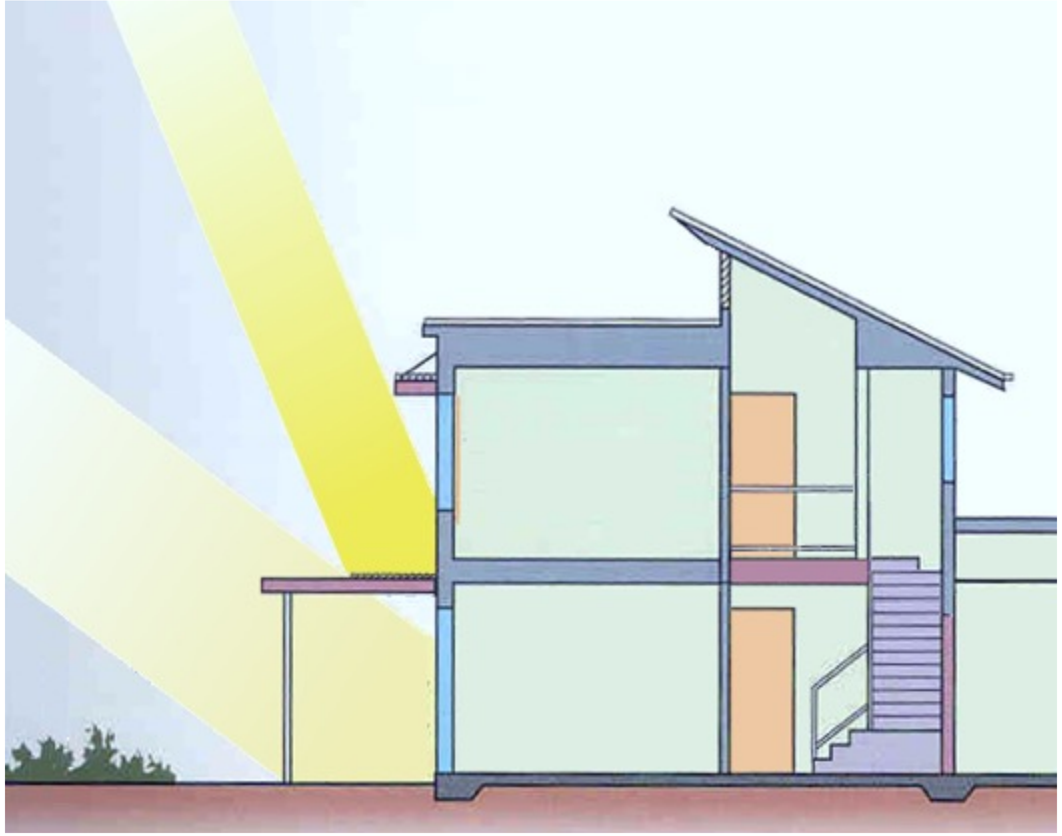
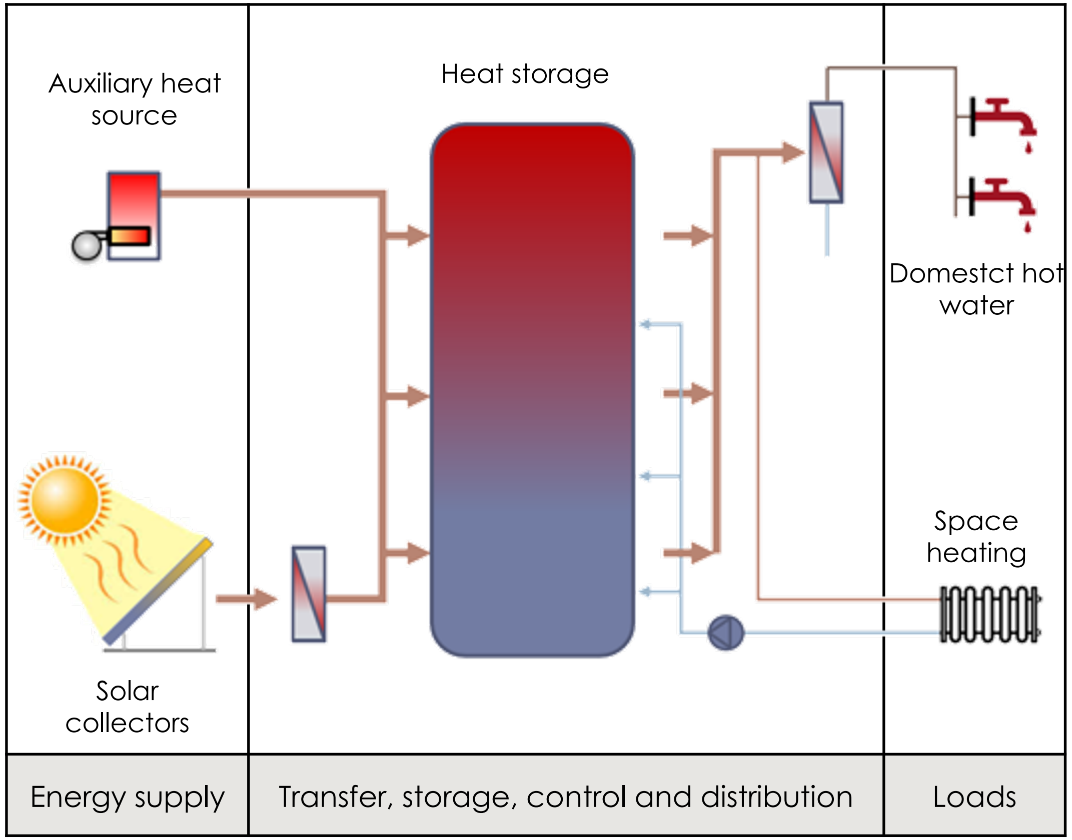
1. Solar thermal

Passive design



Active solar thermal systems



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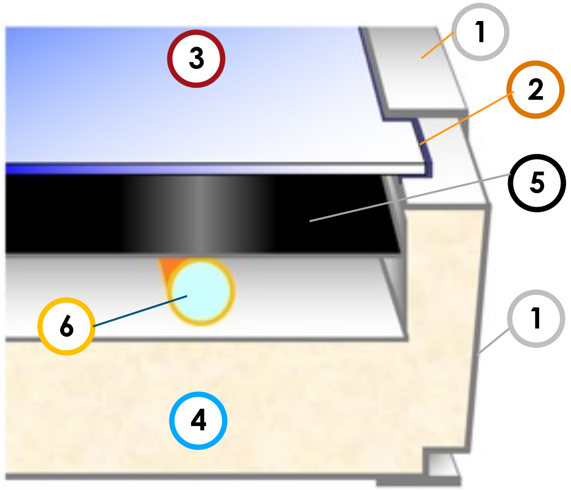
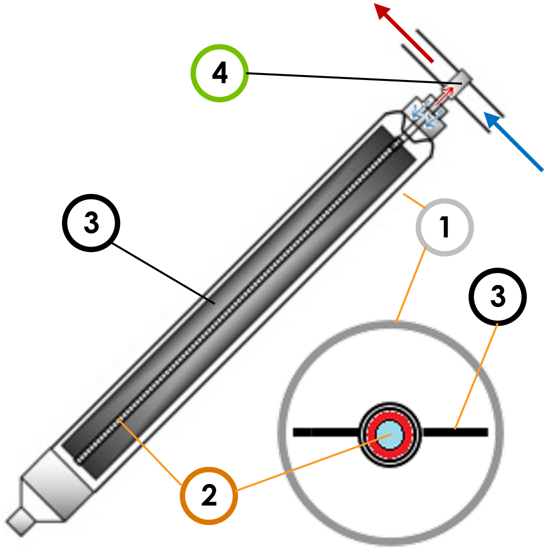
1.1. Solar Collectors

Flat plate



1. Frame
2. Sealing
3. Cover (glazing)
4. Thermal insulation
5. Absorber
6. Fluid pipe

Evacuated vacuum tubes



1. Transparent glass tube (under vacuum)
2. In/out of heat transfer fluid
3. Absorber
4. Heat exchanger/condenser

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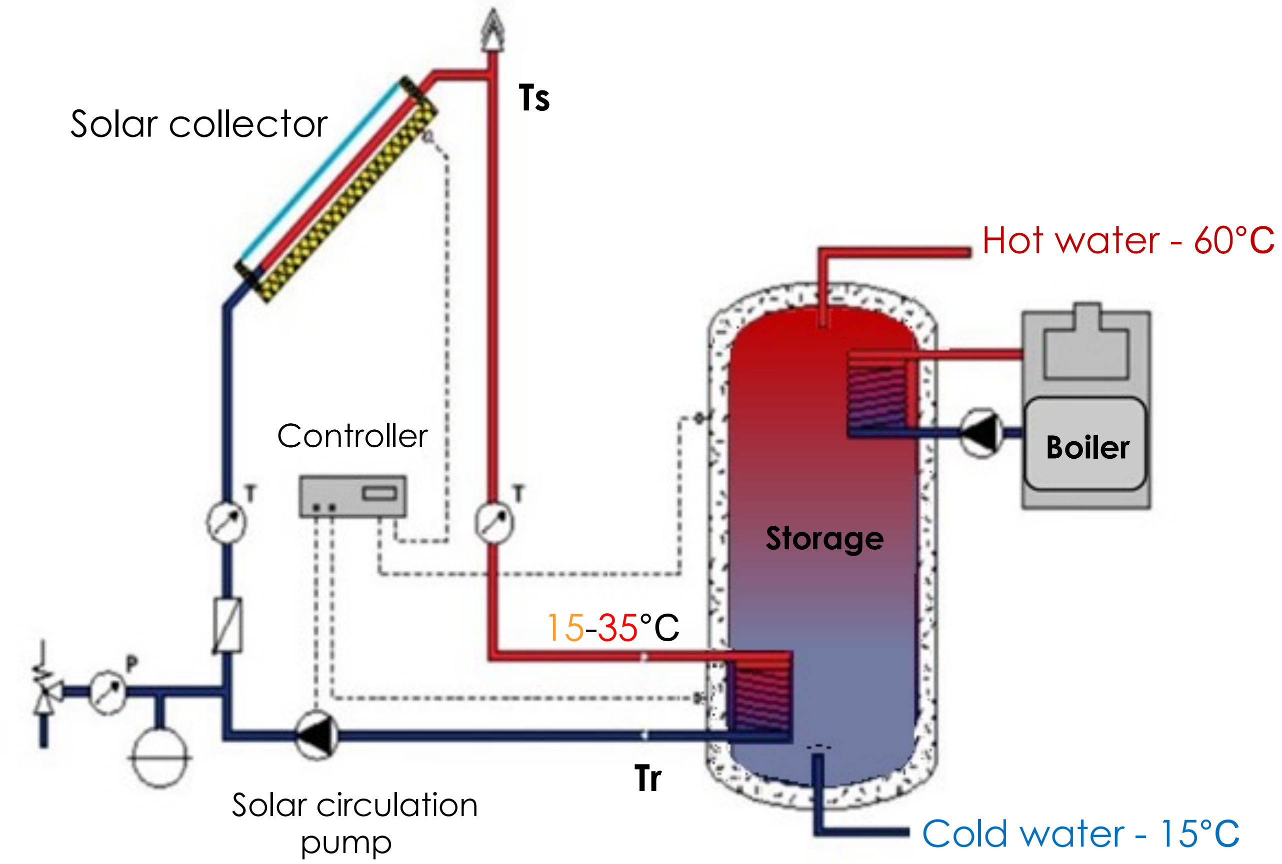
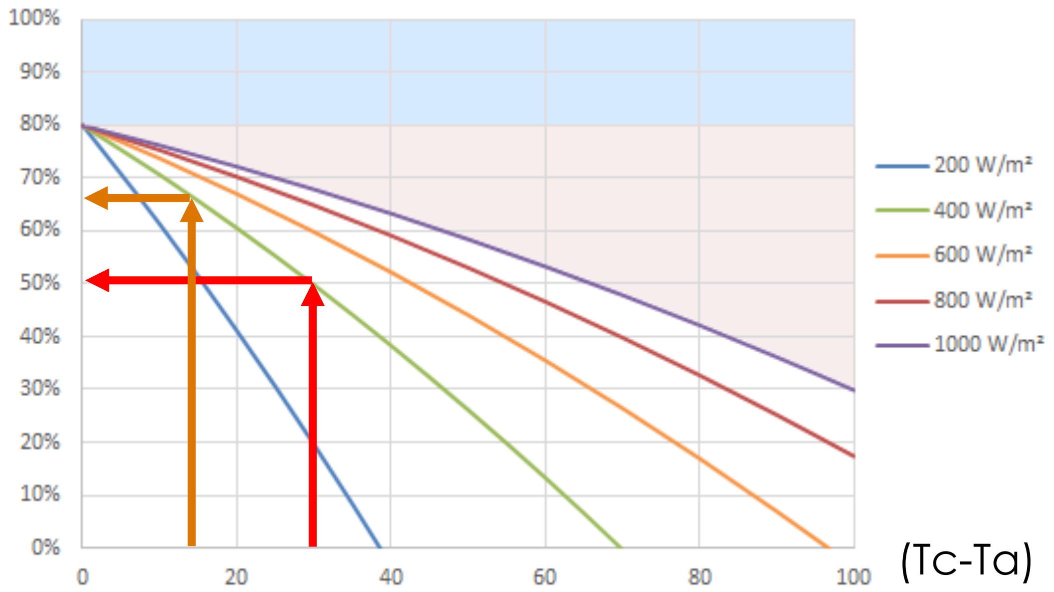
Storage – examples of configurations

Tc – average collector temperature
Ta=15°C ambient temperature
G=400W/m²



Parameter	Good stratification	Poor stratification
Ts	45°C	55°C
Tr	15°C	35°C
Tc	30°C	45°C
Ta	15°C	15°C
(Tc-Ta)	15°C	30°C
η_c	66%	50%



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Simplified sizing for solar domestic hot water

Hot water annual consumption	6500	m³/year
Hot water daily consumption	22	m³/day
Storage temperature	60	°C
Hot water annual consumption	300	MWh/year
Percentage produced by the solar system	25	%

1625m³/year
83MWh/year

1

Domestic Hot water requirements

Hot water daily consumption	22	m³/day
Storage size	31	m³

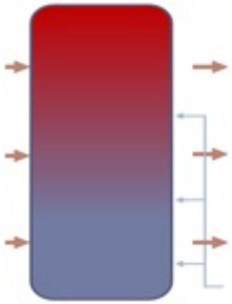
1.5 – 2

coefficient

1.0 – 1.5

2

Storage volume



Daily consumption times coefficient

Unit solar yield	400	kWh/m²
Solar collector surface	208	m²

$$A = \frac{\text{Solar energy}}{\text{Unit solar yield}} \left[\frac{\text{KWh}}{\text{kWh}/\text{m}^2} \right]$$

3

Solar collector area

A= solar collector area

Orientation	Correction
West Southwest	0.84
Southwest	0.92
South Southwest	0.97
South	1
South Southeast	0.97
Southeast	0.85
East Southeast	0.73

Tilt angle	Correction
0	0.85
10	0.89
20	0.92
30	0.975
45	1
50	1
55	0.96
65	0.87

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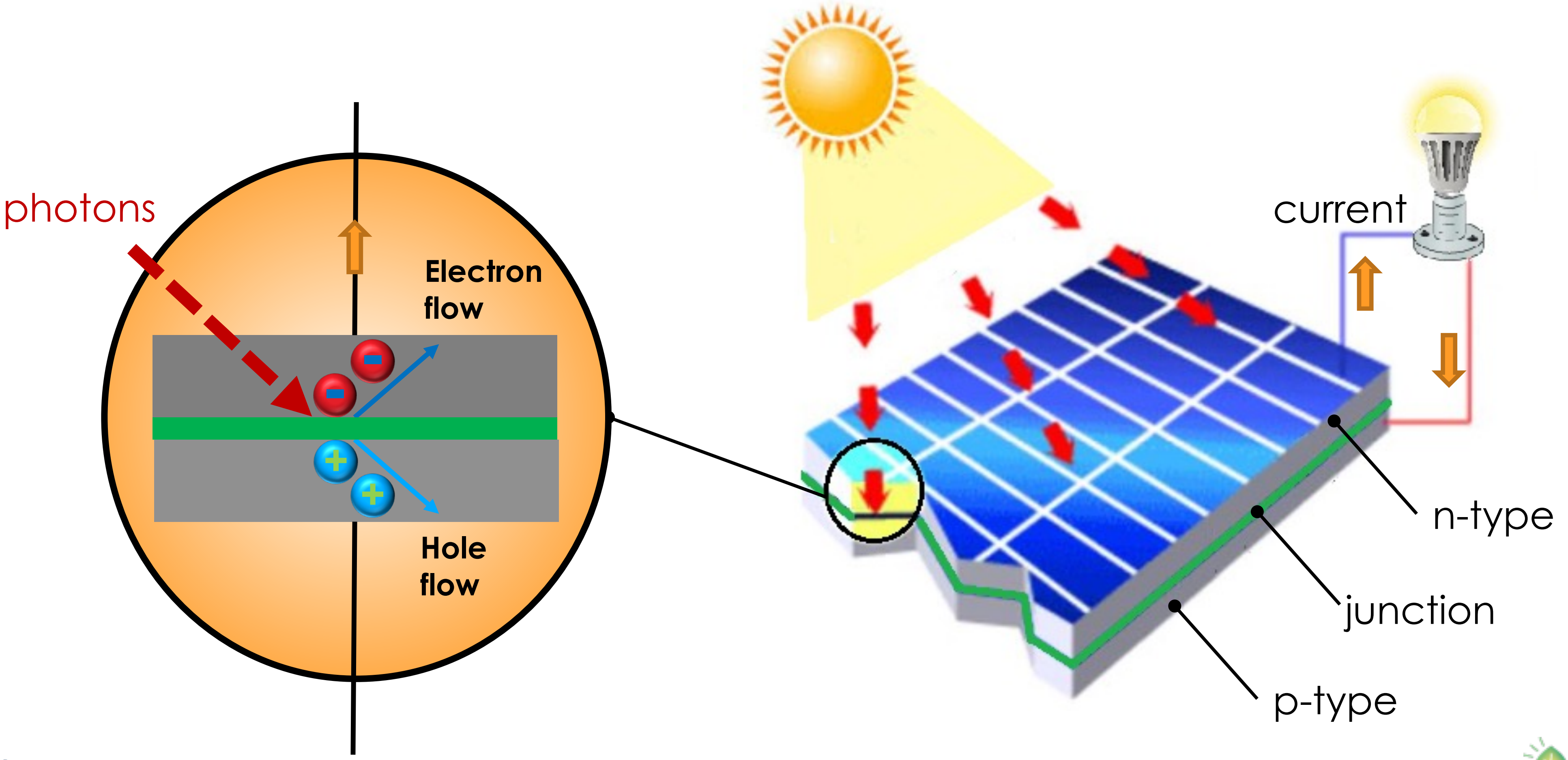
2. Photovoltaic systems basic principle

Photovoltaic effect → direct conversion of sunlight to electricity



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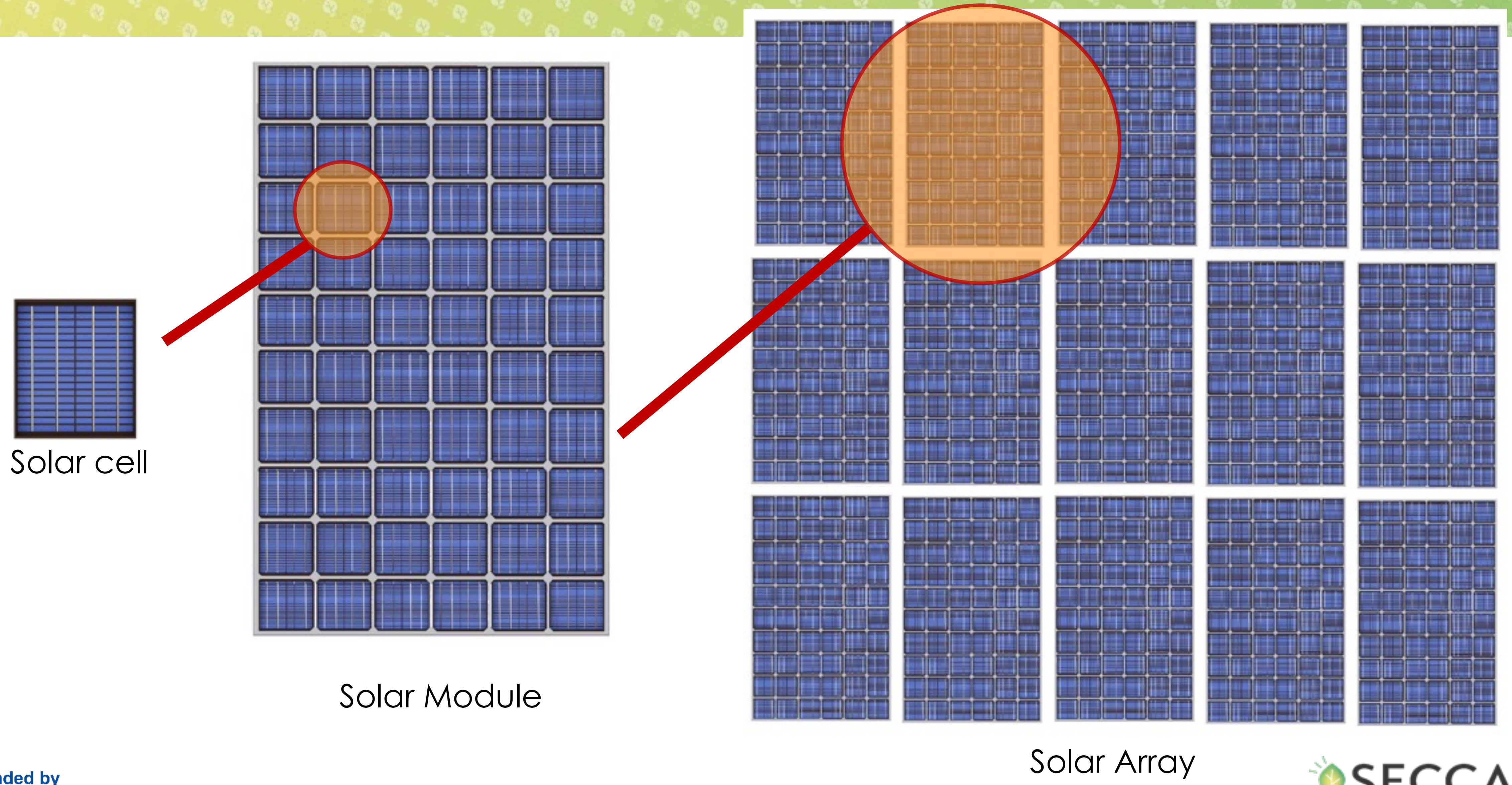
Photovoltaic – cell – module – array



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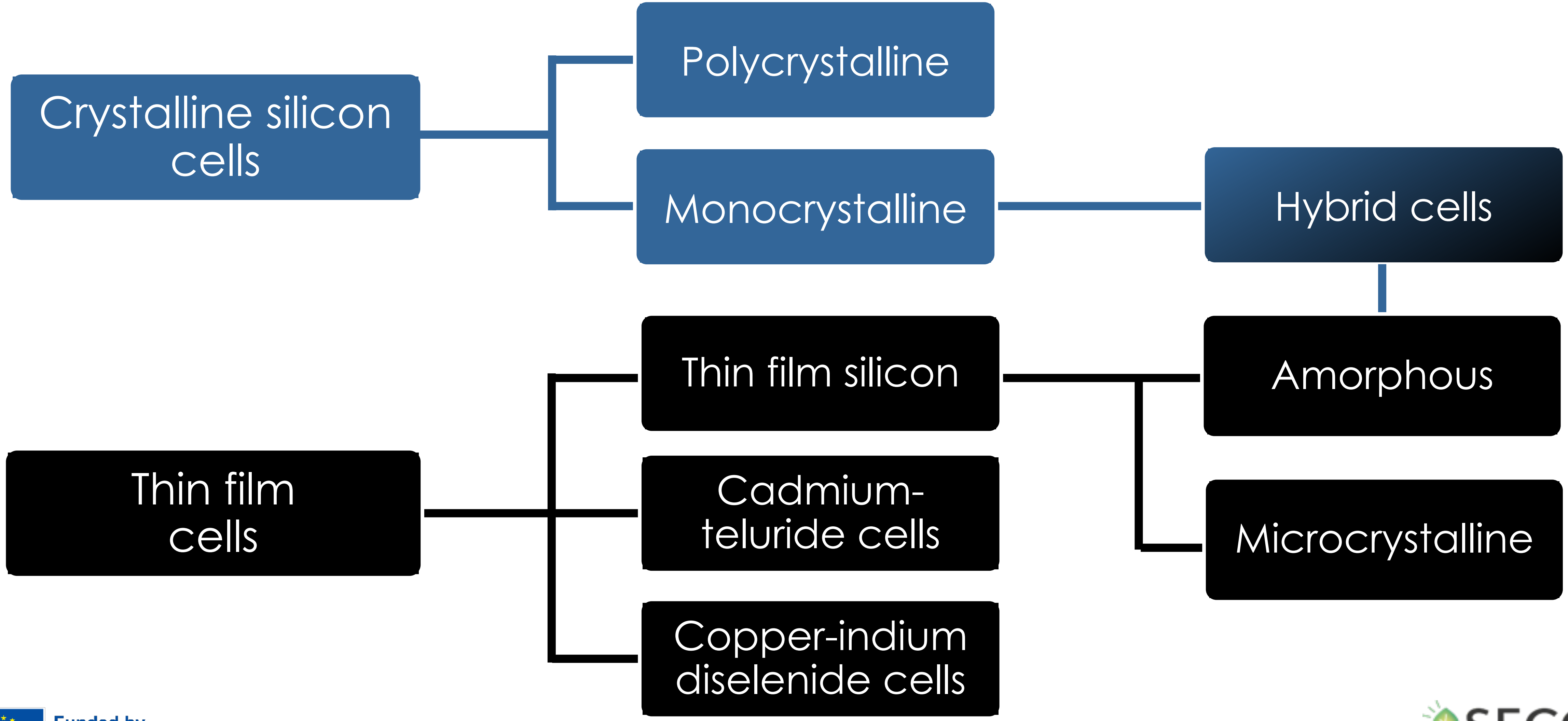
Main PV module technologies



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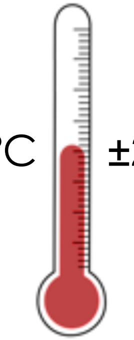
PV module rating

- Standard Test Conditions

Irradiance

1000 W/m²

Temperature

25°C  ±2°C

Reference Spectral Irradiance

Air mass coefficient AM 1.5

100 W Photovoltaic module		
MODEL XXX-000-111-222		
Irradiance	1000 Wm^{-2}	MAXIMUM SYSTEM VOLTAGE 1000V
Cell temperature	25° C	
Pmax	100 W	
Vpmax	18.00 V	
Ipmax	5.56 A	WEIGHT 8kg
Voc	22.10 V	
Isc	5.91 A	
SERIAL number 00A11B2C333333		

- The results from the test are rating inputs for the name plate power
- for comparison of products
- The results are NOT the power for real life operation, or system sizing

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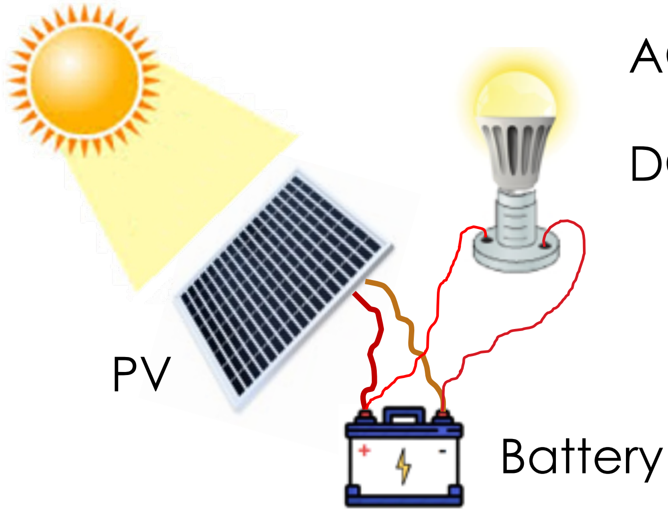
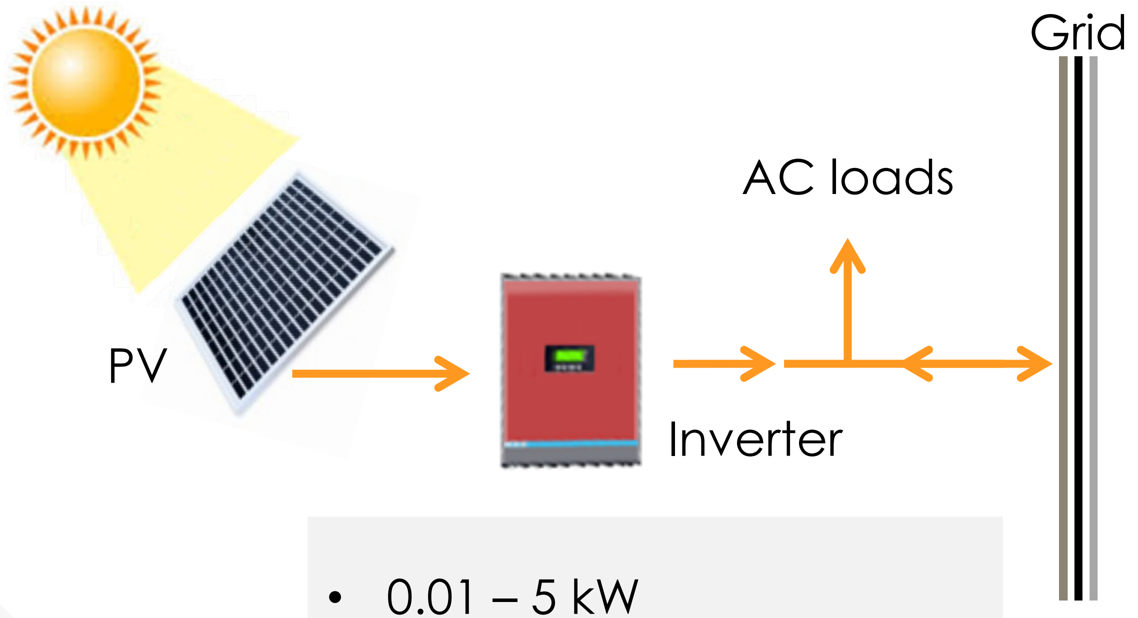
General solar PV set up

Stand-alone systems



Grid connected systems



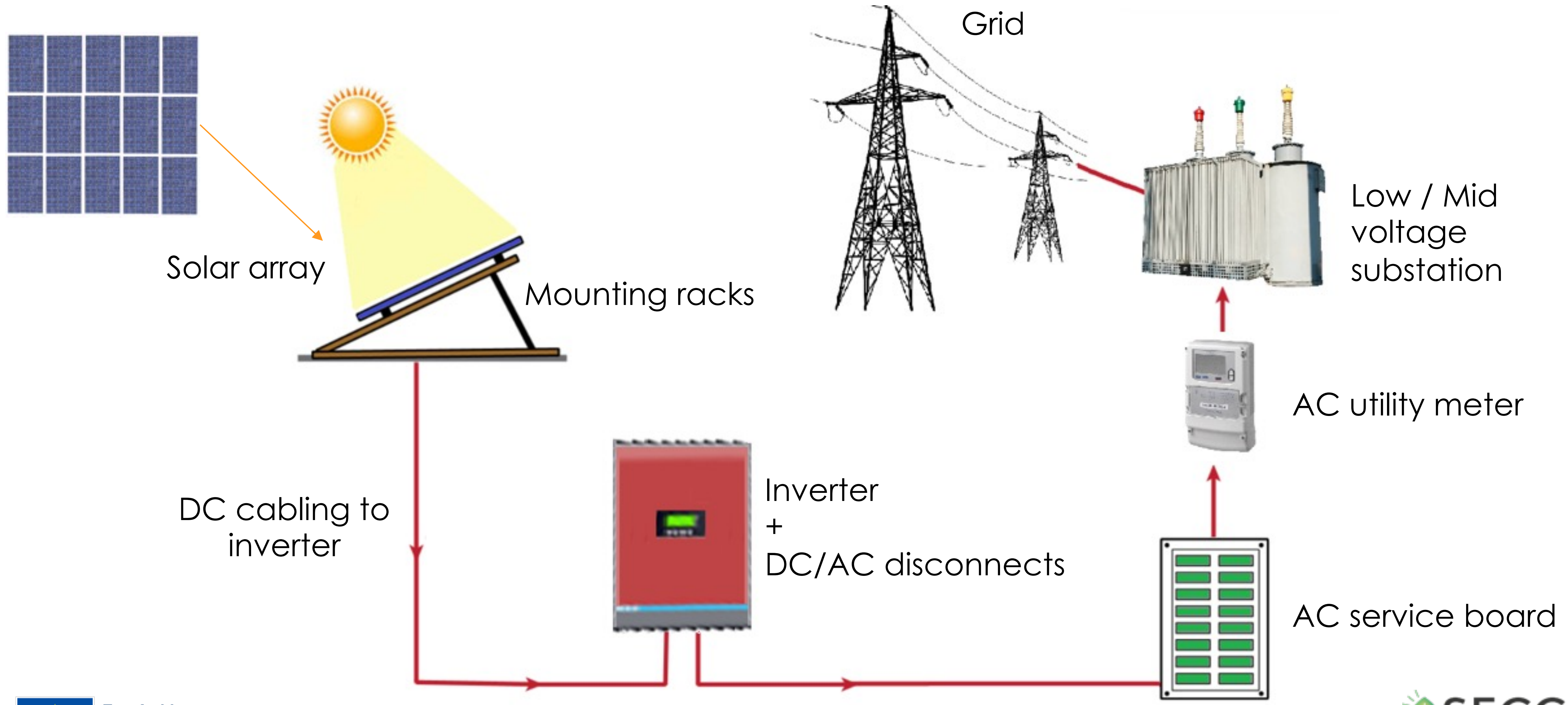
APPLICATIONS:

- Rural electrification
- Mini-grid systems
- Residential house
- Industrial/agricultural roofs
- Utility scale power plants

SIZE:

- 0.01 – 5 kW
- 5-500 kW
- 2-8 kW
- 200 – 5000 kW
- 10 – 1000 MW and more

Grid connected systems



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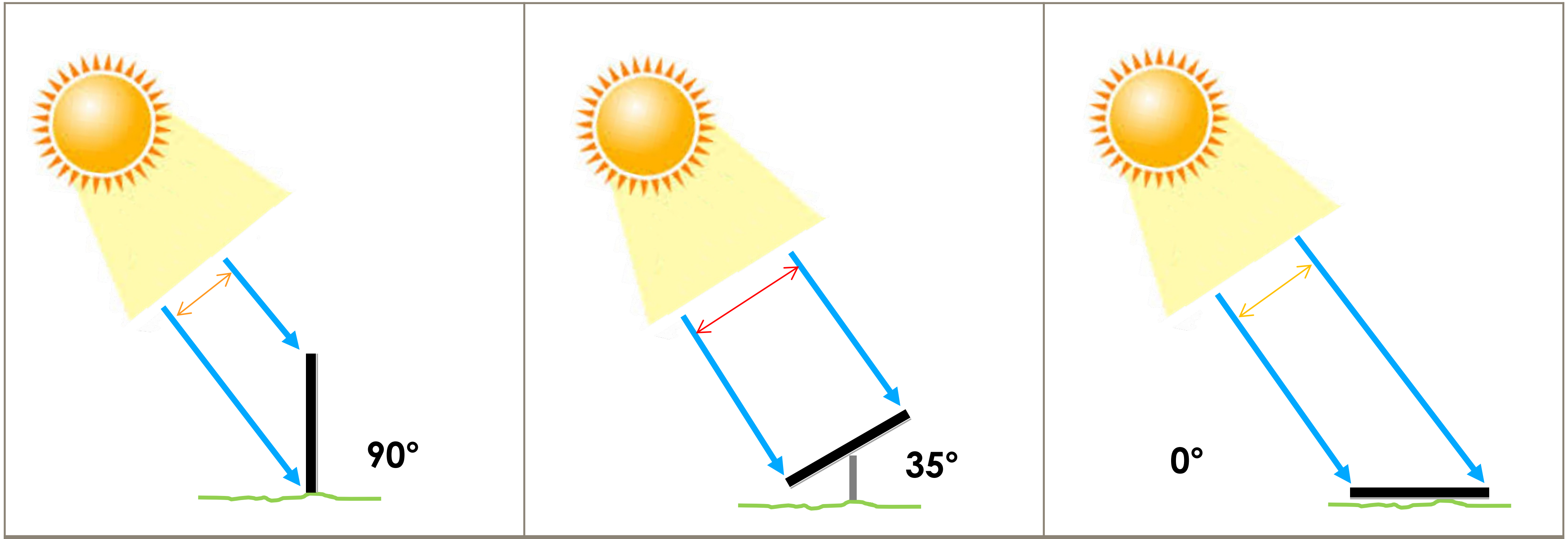
Initial project design

Module tilt and azimuth. Indicative example from Ashgabat with south orientation installation



kWh/kWp 926	kWh/kWp 1467	kWh/kWp 1280

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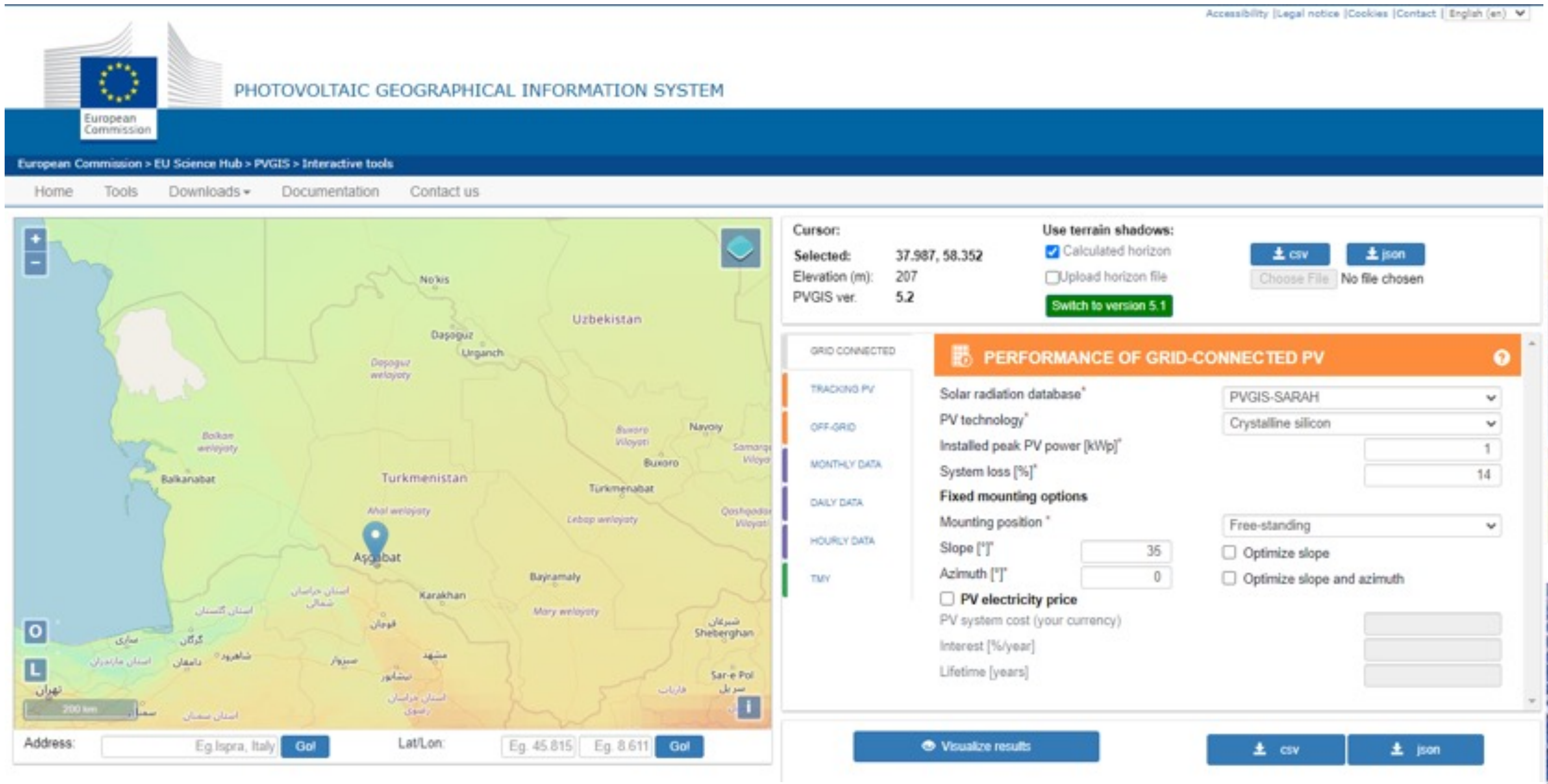
Estimating energy generation – PV GIS



New version at:

http://re.jrc.ec.europa.eu/pvgis.html

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Restaurangen
salt&brygga

SOLAR FOR HEATING AND HOT WATER DISTRICT LEVEL

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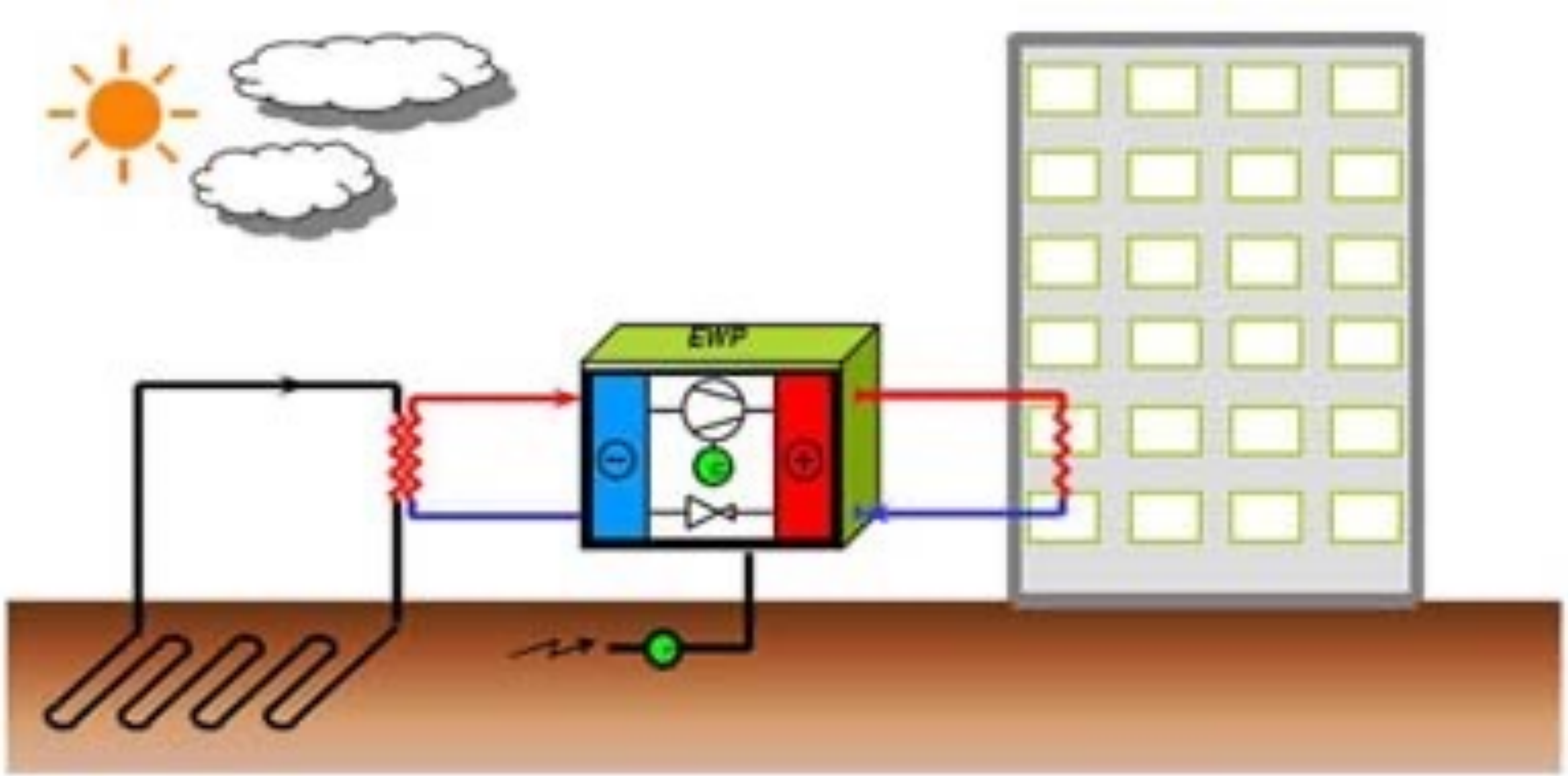
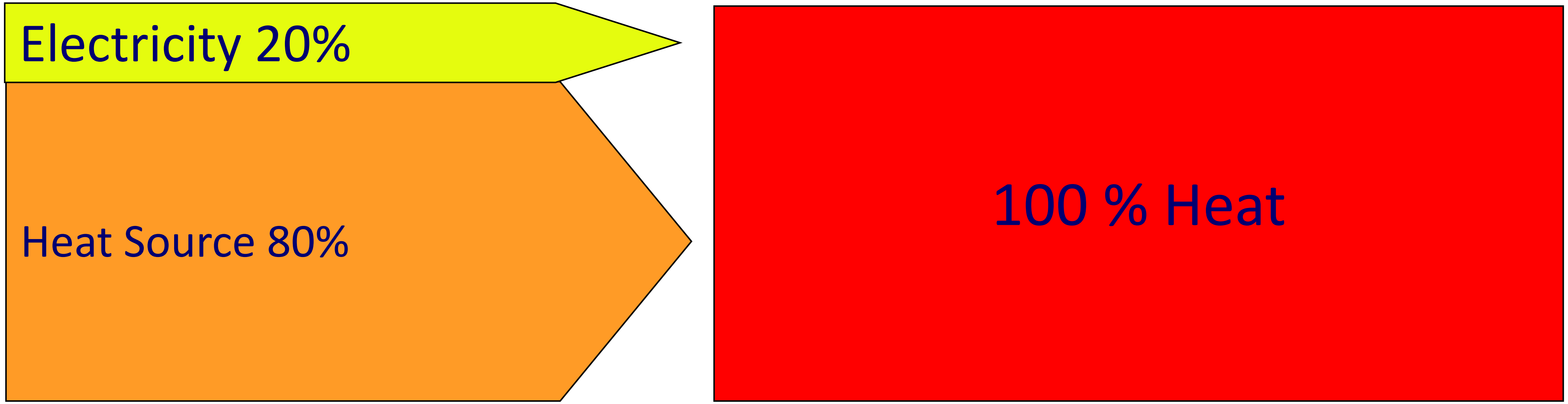
3. Heat Pump Concept

Energy
Source



Coefficient of Performance of a heat pump



Calculation C.O.P.

$$C.O.P = \frac{100\%}{20\%} = 5$$

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Coefficient of Performance = C.O.P

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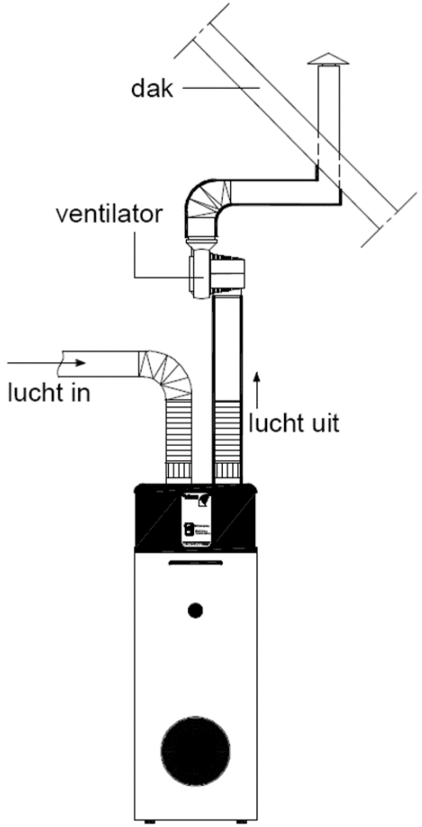
Heat Pump Examples




Heat Pump in Cascade

Heat pump boiler

- Uses Ventilation air energy recuperation
- Suitable for domestic hot water
- One boiler in every dwelling



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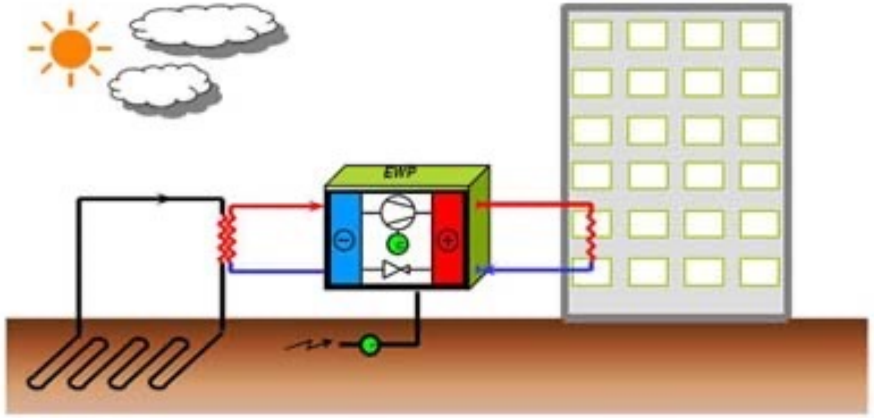
Heat Transmission



Many options possible:

- in floor heating
- heated walls, ceilings
- Radiators

Energy Efficiency of Heat pump system, C.O.P depends on temperature of transmission system

The lower the required temperature, the higher the Coefficient Of Performance of the system

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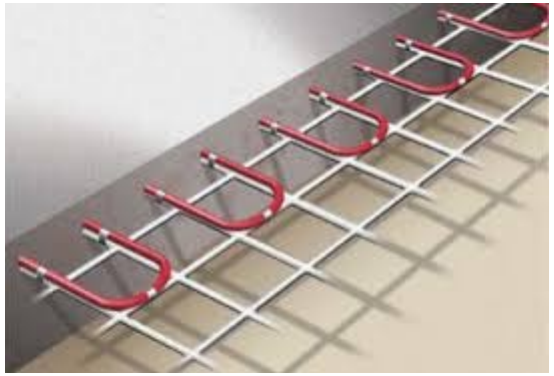
Floor & wall heating



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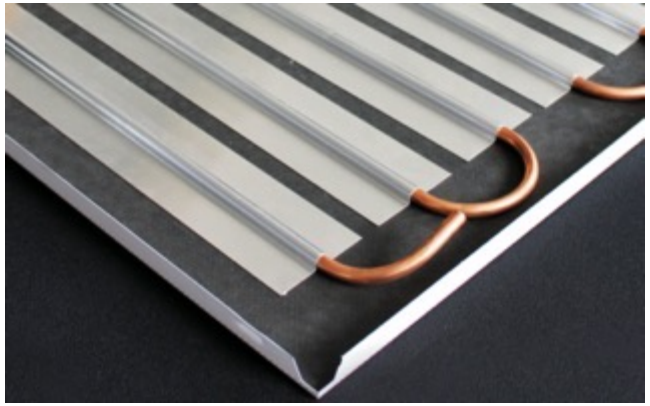
Climate ceilings



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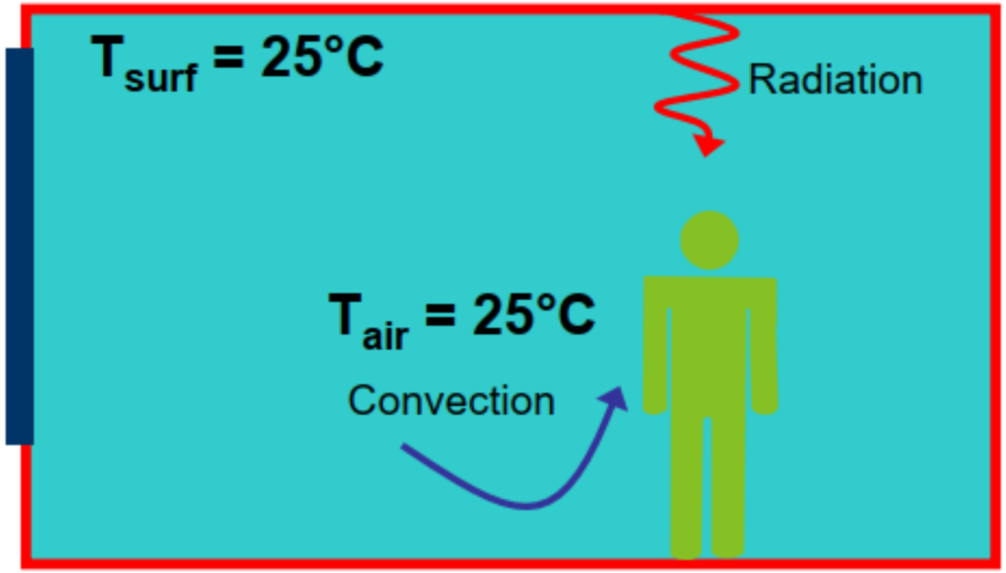
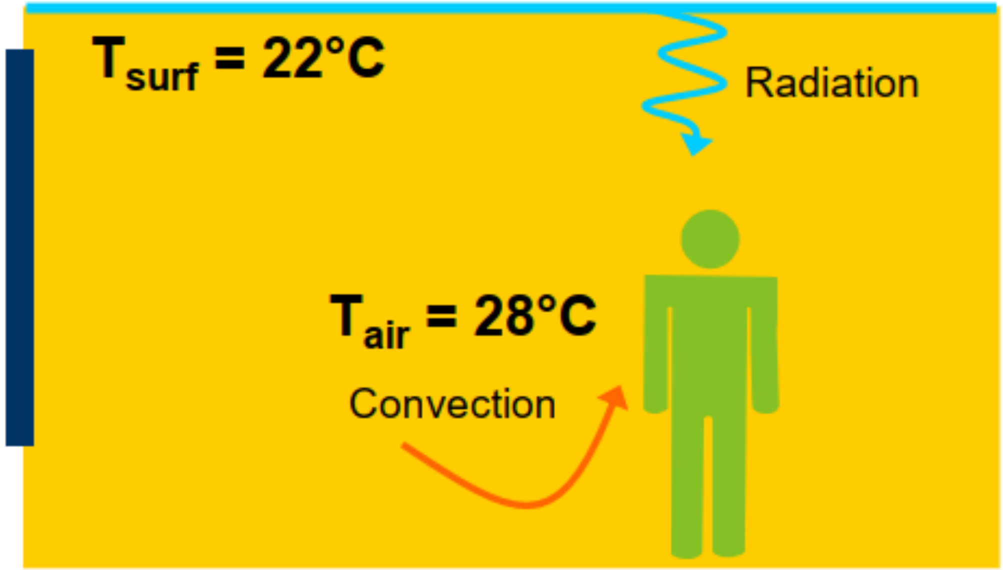
Climate ceilings

Conventionall



=>T_{op} = 25°C

Innovative



=>T_{op} = 25°C

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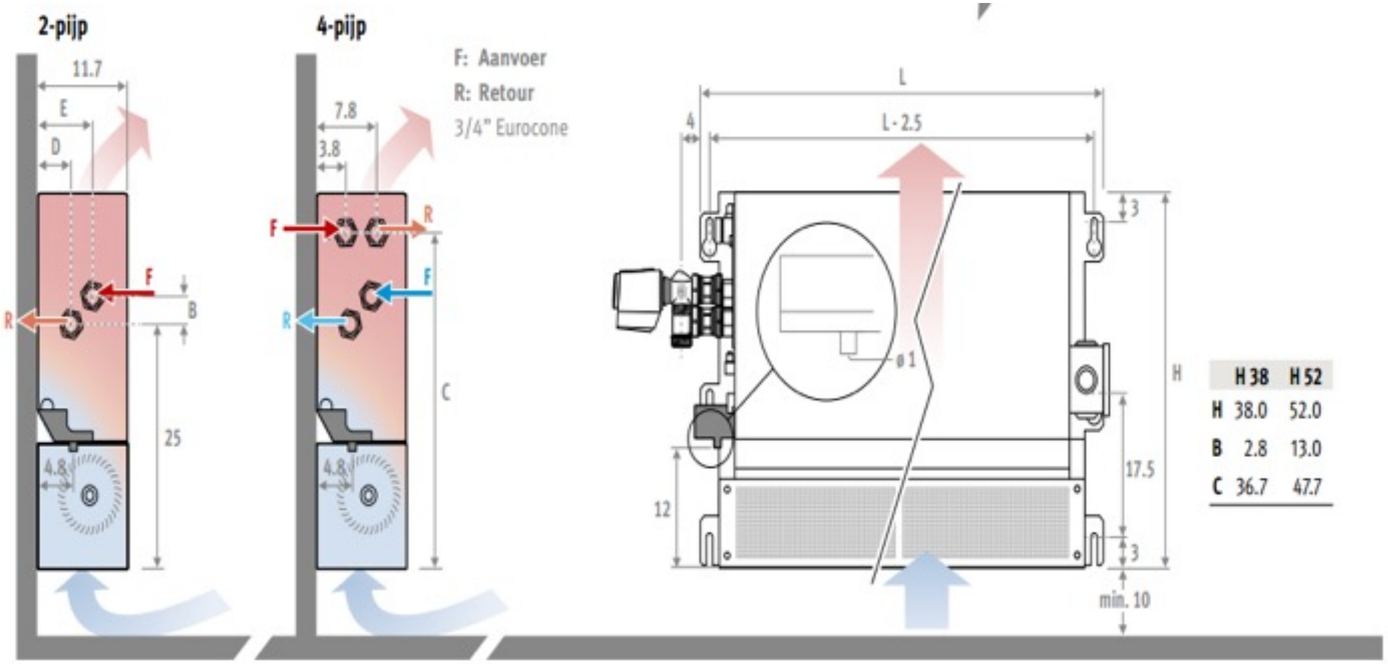
Low Temperature Convectors



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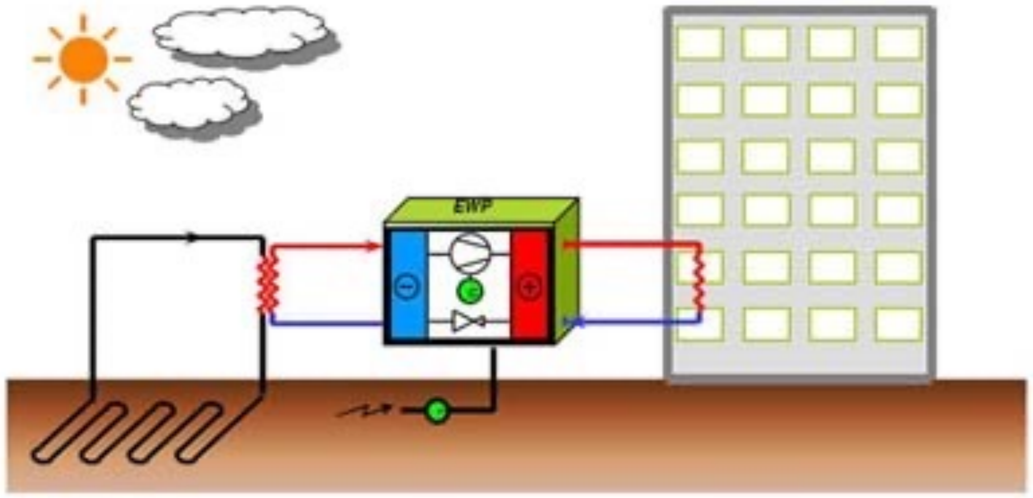
Heat Sources



Many options possible

- Geothermal Energy
- Air
- Open water (Sea, River, Lake)
- Sewerage system
- Roof systems
- Road energy systems

Energy Efficiency of Heat pump system, C.O.P depends on temperature of heat source

The higher the heat source temperature, the higher the Coefficient Of Performance of the system

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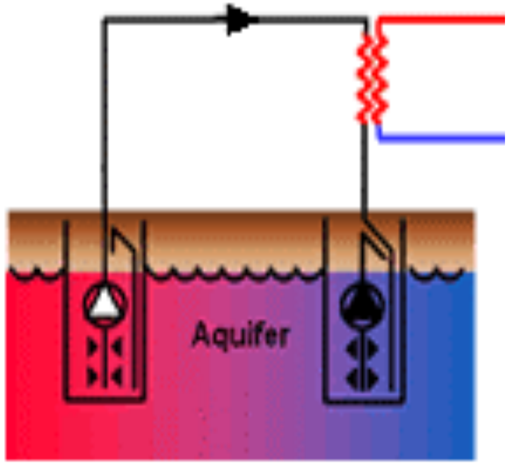
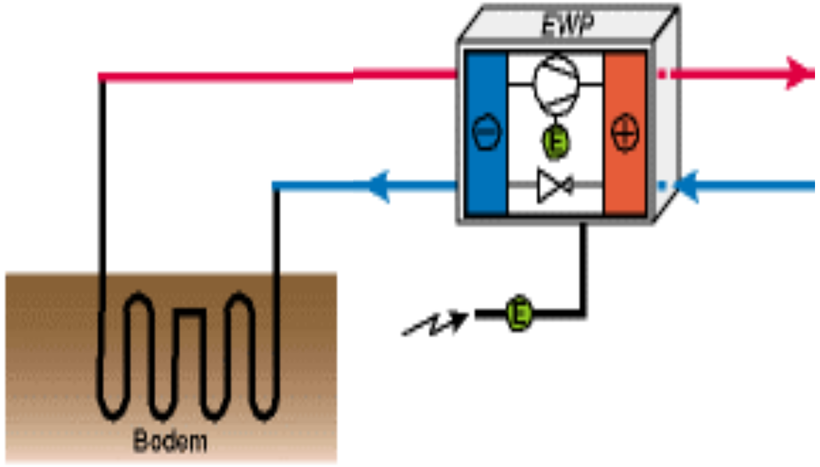
Geo Thermal Primary Energy Source

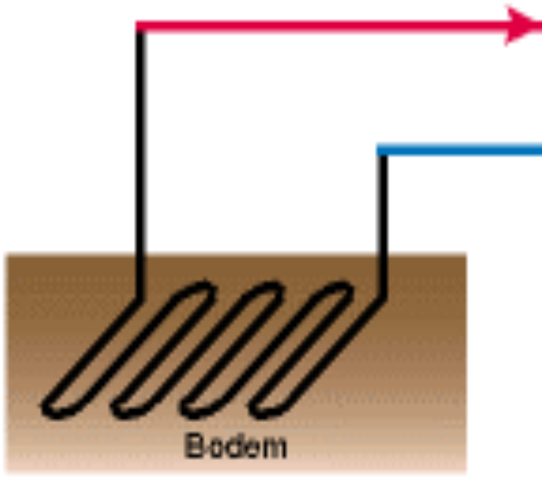
Vertical heat probes



Open ground Water wells (Aquifer)



Horizontal heat probes



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Heat pumps instead of coal boilers

Heat pump for multi-apartment buildings

The temperature of the depths of the earth at a depth of 30-150 m does not depend on the season and is practically unchanged - about 6-9 °C above zero.

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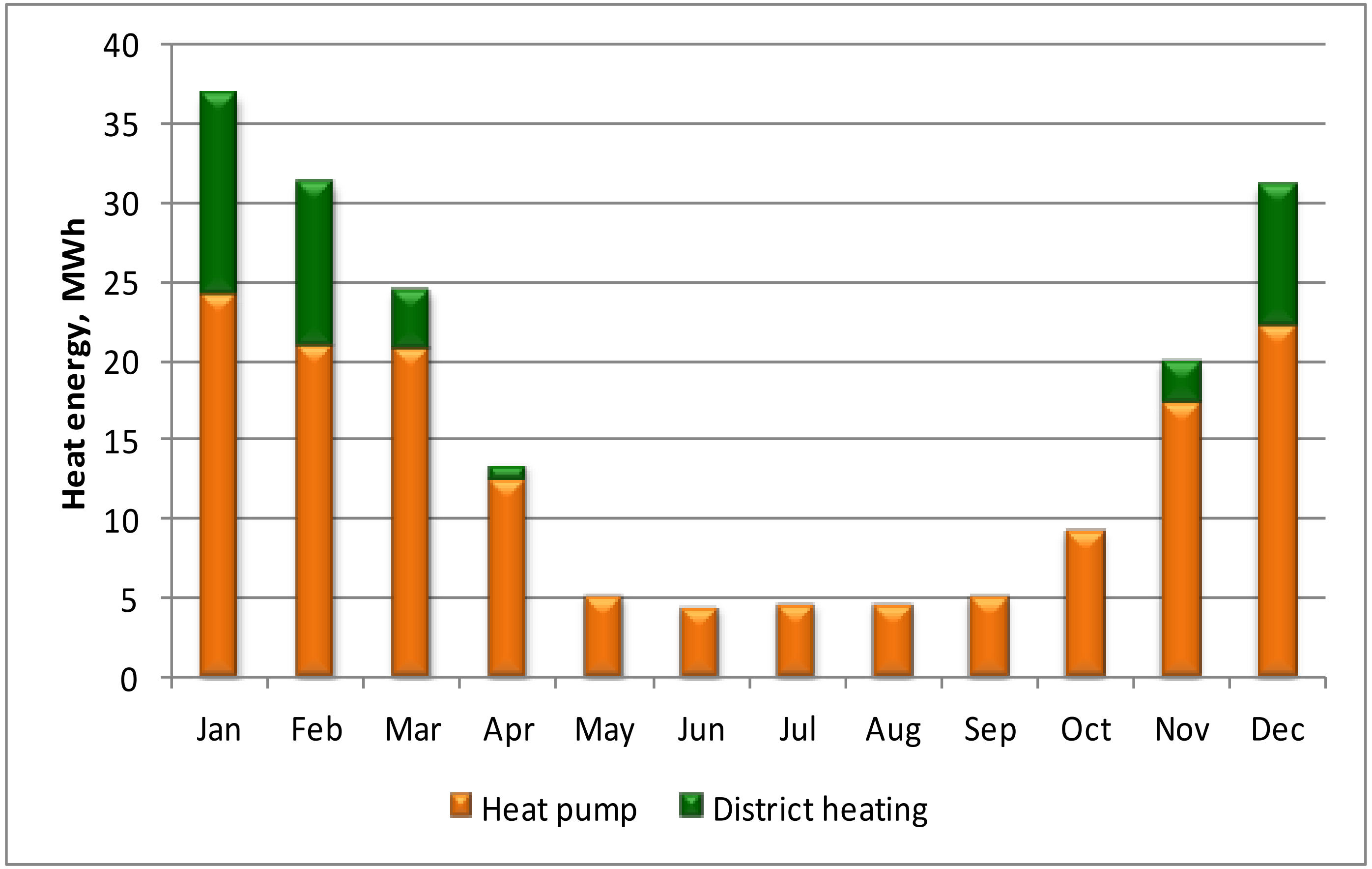
Heat pump and district heating

	Average outdoor temperature °C	Space heating MWh	Hot water & circulation losses MWh	Covered by Heat pump MWh	Covered by District heating MWh
January	-6.1	31.7	5.2	24.2	12.7
February	-5.1	26.6	4.7	21	10.3
March	-0.6	19.3	5.2	20.7	3.8
April	5.6	8.4	5.1	12.5	1.0
May	12.0	0.0	5.2	5.2	0.0
June	15.9	0.0	4.5	4.5	0.0
July	17.3	0.0	4.7	4.7	0.0
August	16.4	0.0	4.7	4.7	0.0
September	11.4	0.0	5.1	5.1	0.0
October	6.8	4.0	5.2	9.2	0.0
November	1.3	14.9	5.1	17.3	2.7
December	-3.6	26.0	5.2	22.3	8.9
Total		130.9	59.9	151.4	39.4



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