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technische THERMO DYNAMIK

BrineRIS

Brines and mine water geothermal energy - a green energy source for different heat sinks

Freiberg 10th – 11th May 2023

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tTD technische THERMO DYNAMIK

Self-generation and self-use of renewable energy/ geothermal energy (heating, cooling and electricity)

Timm Wunderlich, Lukas Oppelt, Tom Ebel, Thomas Grab

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10.05.2023

BRINE RIS

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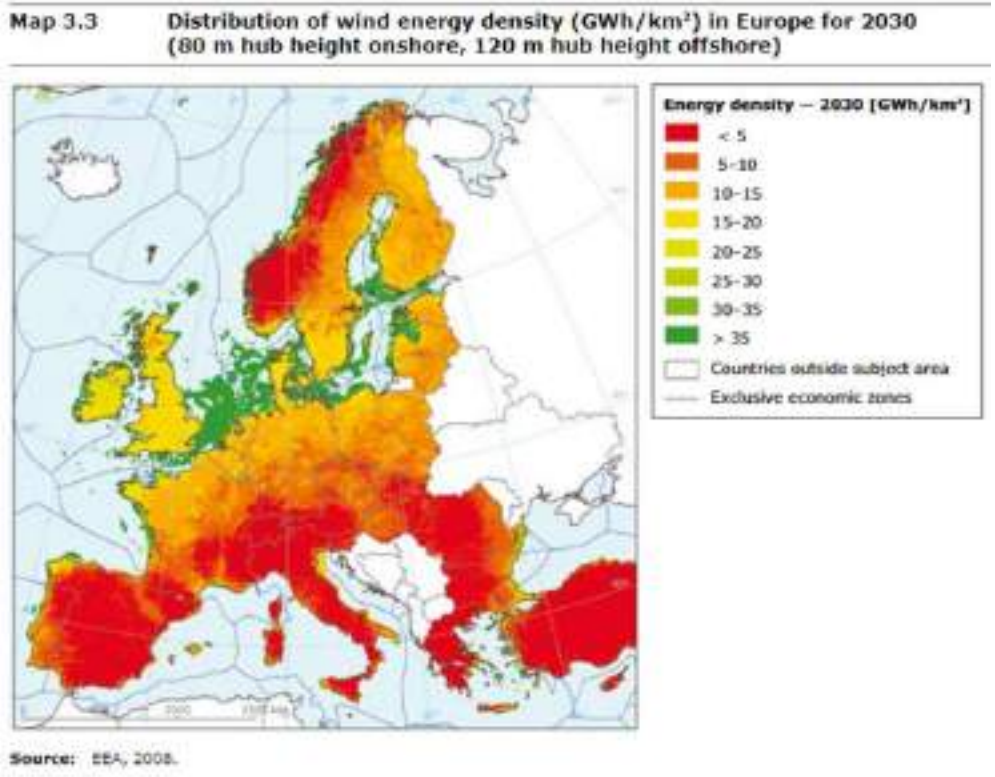
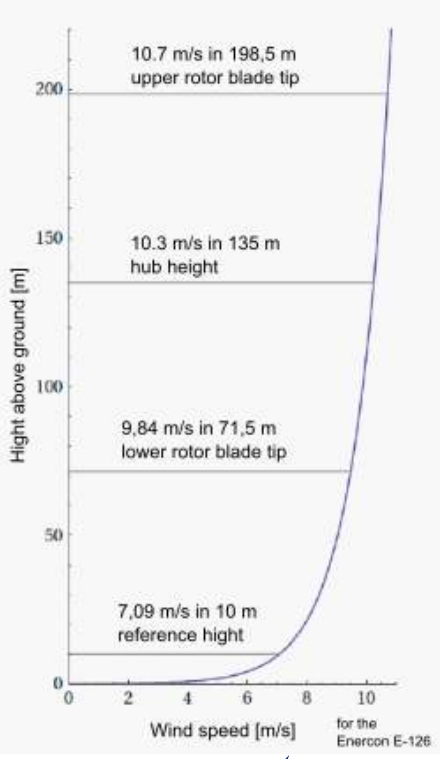
1. Overview of regenerative energy sources

1.1 Wind



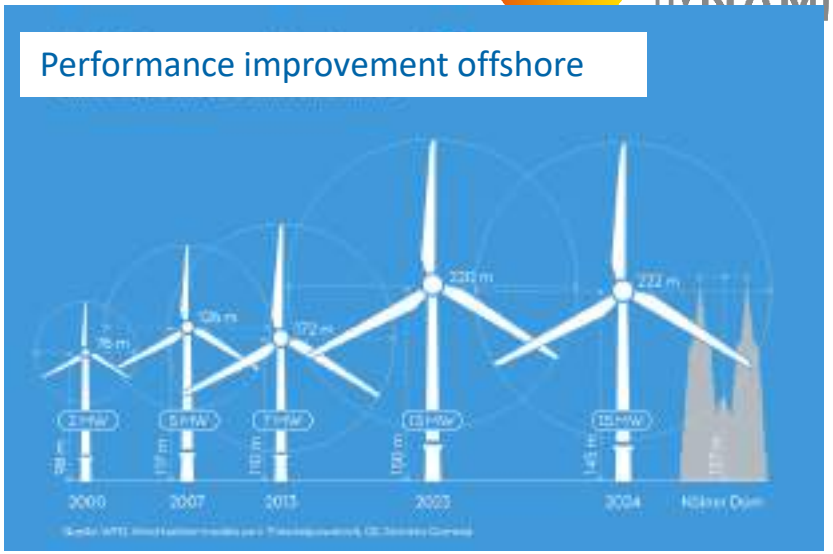


1. Overview of regenerative energy sources

1.1 Wind

2021: 236 GW installed capacity in europe
437 TWh amount of elec. energy

2021 new construction 14,0 GW onshore,
3,3 GW offshore



Onshore

A increase in wind speed in central europe and western europe

- Potential: 45 000 TWh EEA countries

Offshore

Atlantic, Baltic Sea North Sea

- Potential: 30 000 TWh

ISSN1725-2237 Europe's onshore and offshore wind energy potential

1. Overview of regenerative energy sources

1.2 Water

Potentials of hydropower utilisation worldwide

- Installed capacity in GW
- Estimated generation in 2016 in TWh per year
- Max. assumed generation

Quelle: Hydropower status report 2017 (iha), S. 32f.

1. Overview of regenerative energy sources

1.2 Water

https://www.landeskraftwerke.bayern/kraftwerkstypen.htm

: Hydropower status report 2017 (iha), S. 32f.

Most important countries in Europe by installed hydropower capacity in 2021

Share in the national electricity mix in 2021

Country	Germany	France	Italy
percentage	3%	10%	16%
Country	Spain	Sweden	Austria
percentage	11%	42%	56%

- Installed capacity in GW
- Estimated generation in 2016 in TWh per year
- Max. assumed generation

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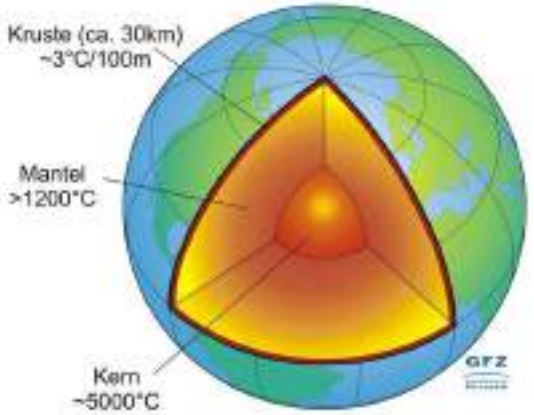
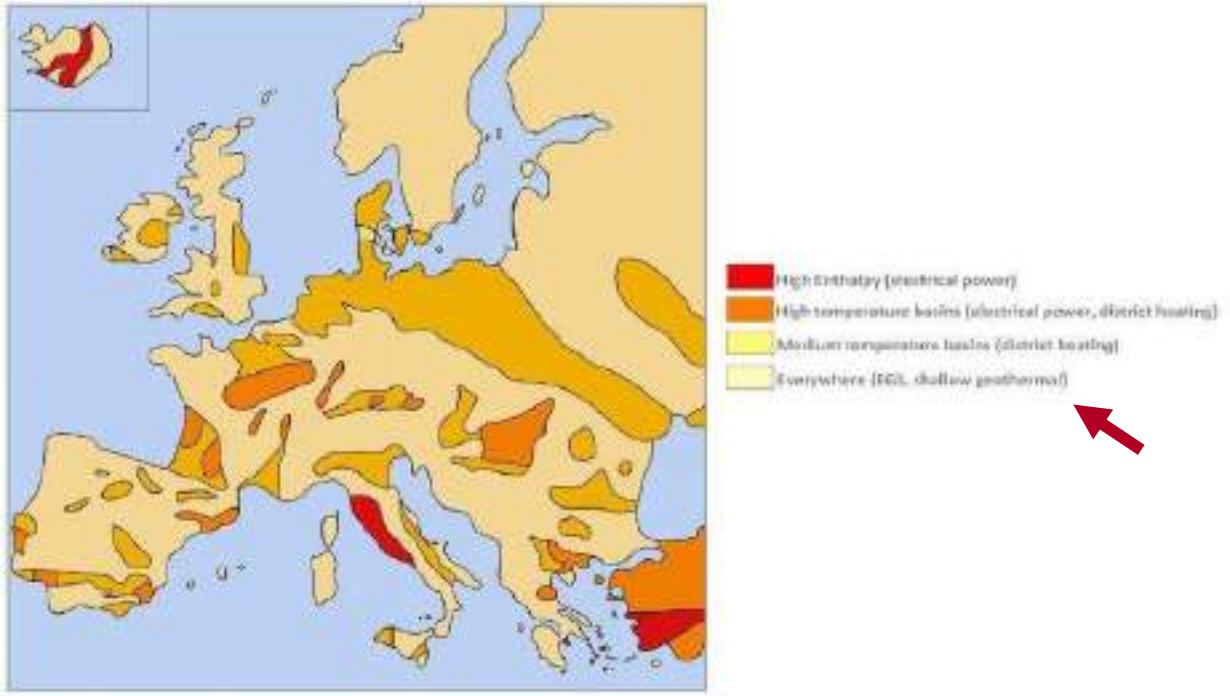
1. Overview of regenerative energy sources

1.3 Geothermal energy

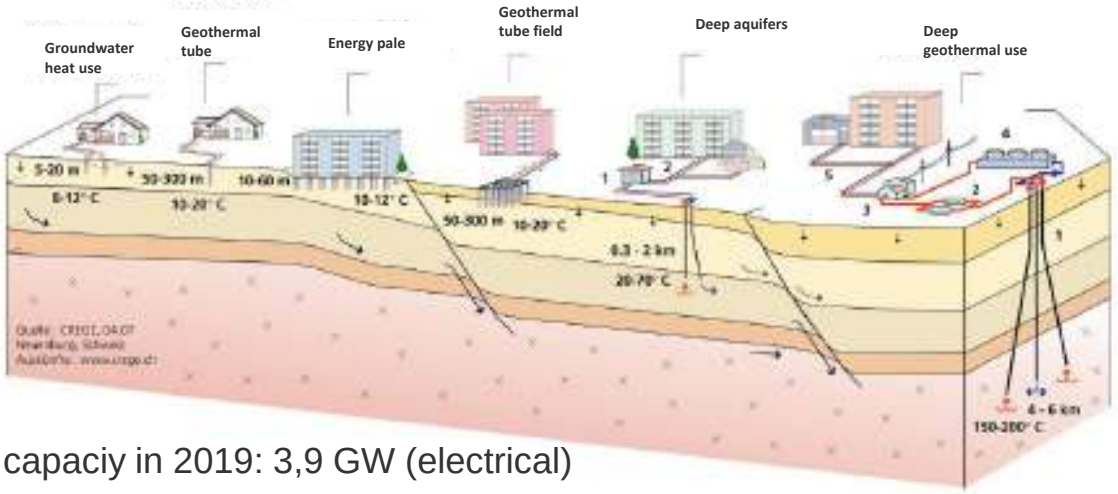


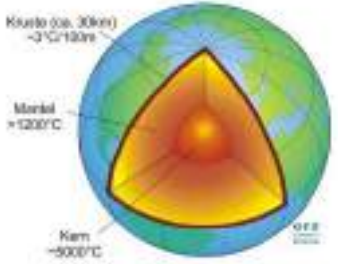
Soure: Geoenergy-celle.de



1. Overview of regenerative energy sources

1.3 Geothermal energy

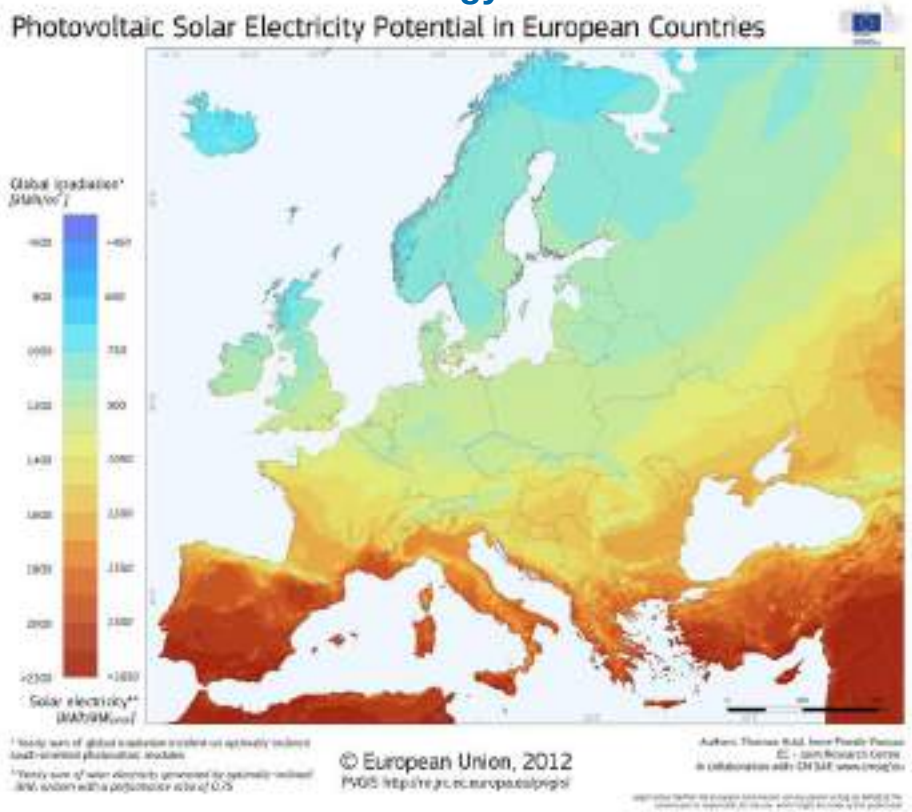




- Installed capaciy in 2019: 3,9 GW (electrical)
- Usable Power 19,3 TWh
- No significal rate of increase
- energy stored beneath the solid surface of the earth
- Temperature increase at approx. 3°C per 100 m depth.
- "Conduction" - heat flow from the Earth's core and natural radioactive decay
- "Convection" - heat flow via groundwater flow

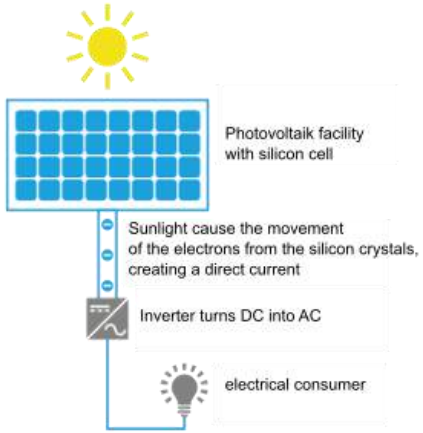
1. Overview of regenerative energy sources

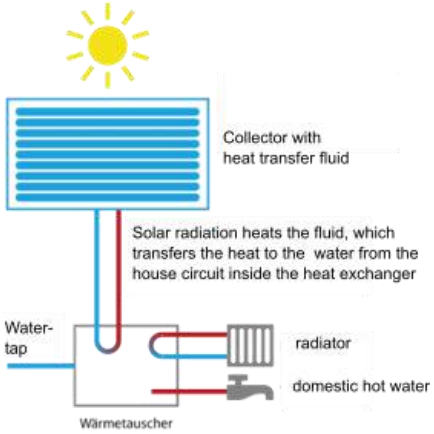
1.4 Photovoltaic and Solarthermal Energy



1. Overview of regenerative energy sources

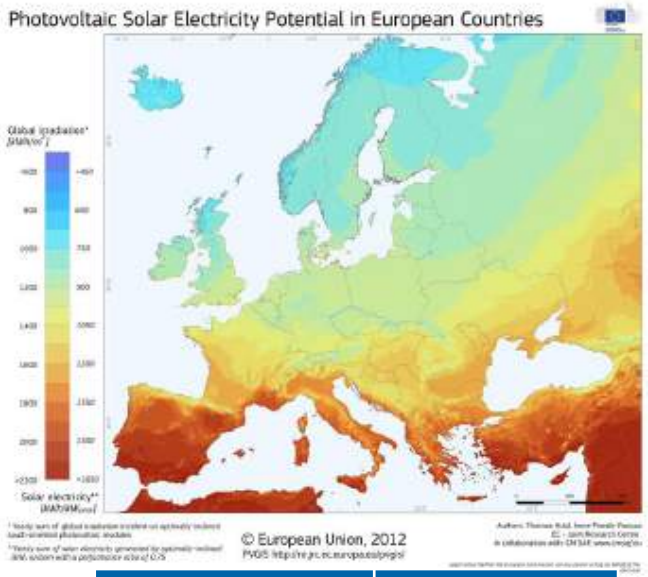
1.4 Photovoltaic and Solarthermal Energy





Cumulative capacity in 2017: 106 GW
Annual energy generation: 215,9 TWh
Usable roof toop: 7.935 km²

Cumulative capacity in 2019: 37 GW
Annual energy generation: 26,3 TWh



location	Energy gain [kWh/kWp]
Germany (Bonn)	940
Bulgaria (Sofia)	1.270
Spain (Madrid)	1.580

Rooftop: 680 TWh_{el} 24,4 % of all EU

https://www.iwb.ch/Themen/solar-magazin/Artikel/Was-ist-der-Unterschied-zwischen-Photovoltaik-und-Solarthermie.html

Source: Solar Heat Markets in Europe ESTIF 2019

1. Overview of regenerative energy sources

1.5 Others

- Biomass

stock.adobe.com/fotograupner

https://www.solvis.de/pelletheizung/

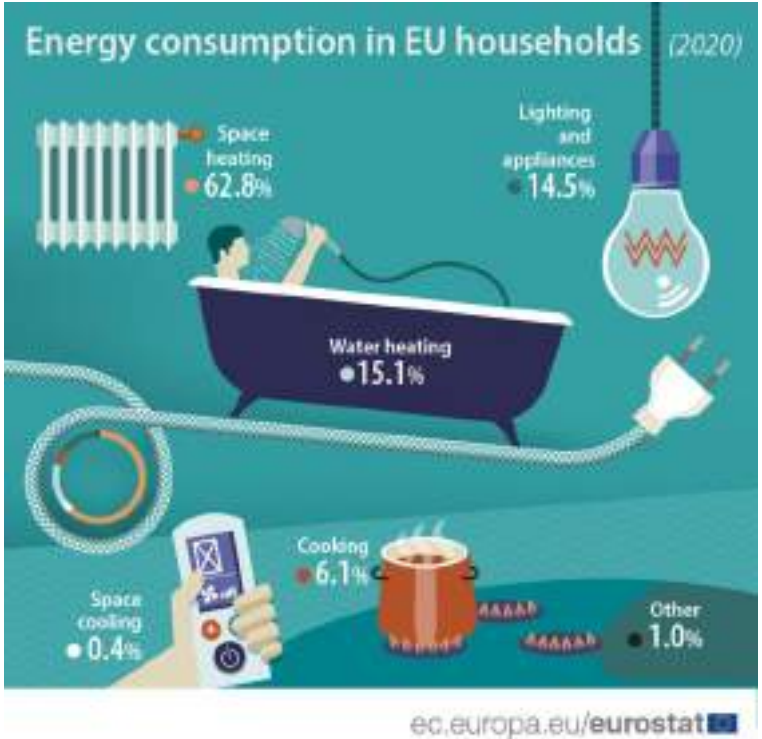
- Wood
- Tides

- Air
- And more

Source: picture-alliance/dpa/dpa

Energy demand in buildings

Status quo – energy consumption

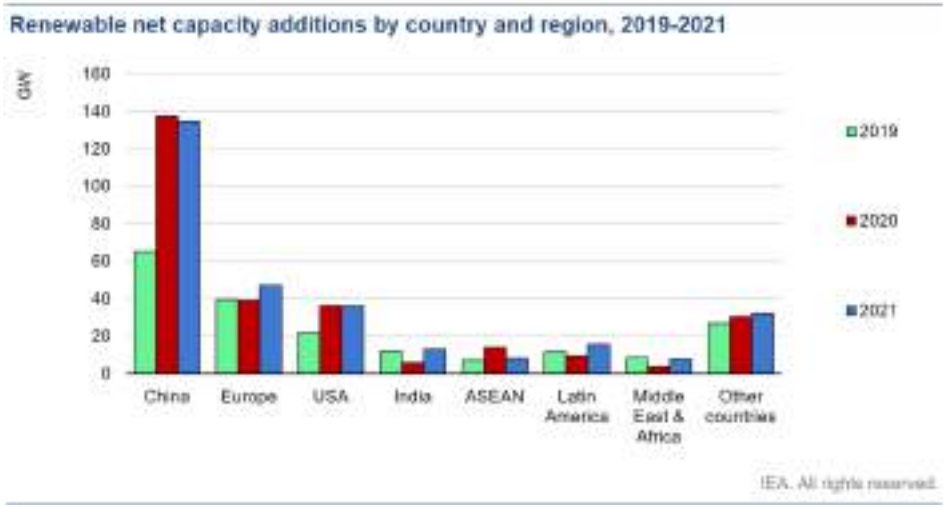


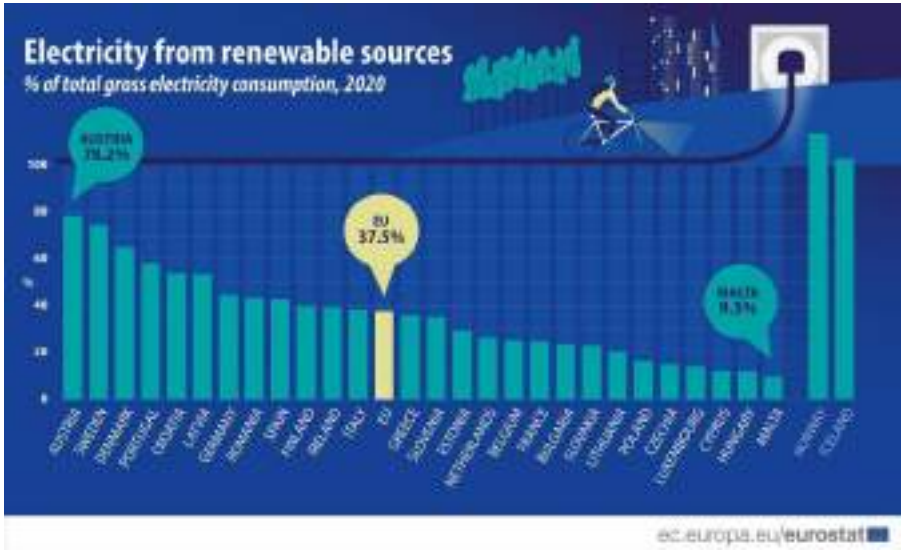
- **Germany:**
  - El. energy: 2,000-5,000 kWh per houshold → 1-4 persons
  - Heating/Cooling: 7,000-30,000 kWh per houshold → depending on flat-area and age building
- **Spain:**
  - El. energy: ≈ 10,300 kWh per houshold
  - Heating/ Cooling: part of. El. Consumption ≈ 7,000 kWh

Source Dtl.: https://www.destatis.de/EN/Themes/Society-Environment/Environment/Material-Energy-Flows/Tables/electricity-consumption-households.html
Source Sp.: https://mediterraneoglobal.es/en/housing/energy-consumption-in-spanish-households/

Energy demand in buildings

Status quo – electrical energy





- Worldwide expansion of renewables for power generation (especially China, EU, USA)
- Still only about 37% in Europe → expansion must be accelerated

Source left: International Energy Agency: Renewable Energy Market Update, Outlook for 2022 and 2023
Source right: https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20220126-1

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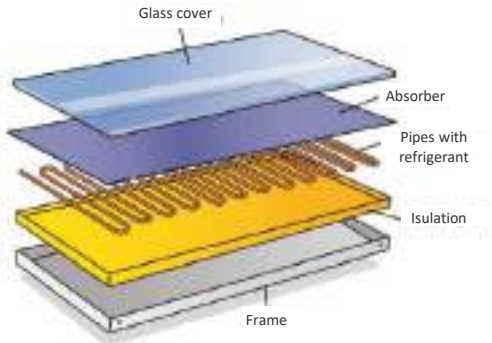
Use of solar energy

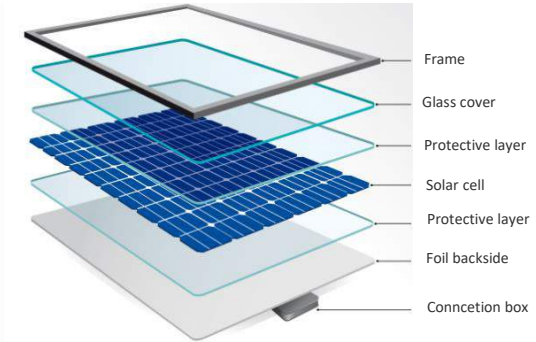
Focus on solar and geothermal energy for use in households!

Heat



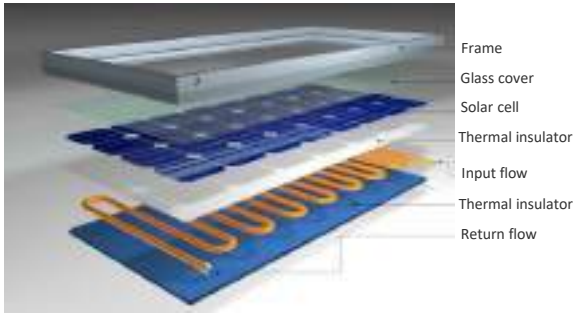
https://www.solaranlage-ratgeber.de/solarthermie/solarthermie-technik/solarthermie-kollektoren-im-vergleich

Electricity



https://sonnenstrom365.de/was-ist-pvt/

Heat/Electricity

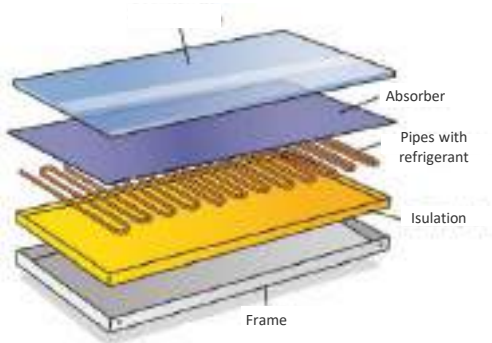


https://echtsolar.de/photovoltaik-aufbau/

Use of solar energy

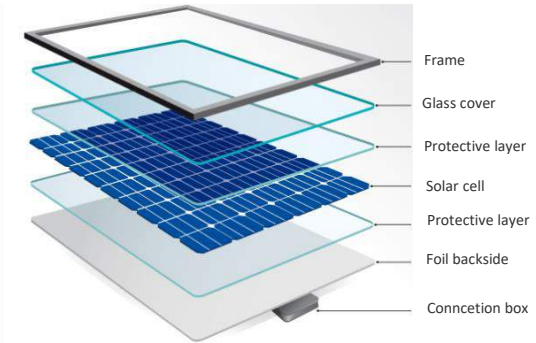
Focus on solar and geothermal energy for use in households!

Heat



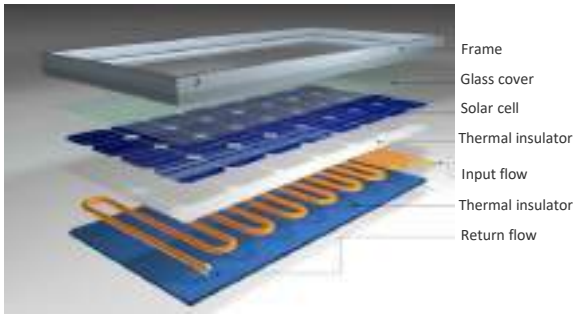
https://www.solaranlage-ratgeber.de/solarthermie/solarthermie-technik/solarthermie-kollektoren-im-vergleich

Electricity



https://sonnenstrom365.de/was-ist-pvt/

Heat/Electricity



https://echtsolar.de/photovoltaik-aufbau/

SOLARWATT Panel vision AM 4.0 black	
Solar cells	Monocrystalline cells
Max. Rated power P_max (STC)	400 Wp (Watt-peak)
Rated power P_max (NMOT)	322 W
Module efficiency	20,5%

https://www.solarwatt.de/loesungen/unsere-produkte/uebersicht/module#aufs-dach

PVT Solar Hybridkollektor BlackDiamond BSM-425	
Solar cells	Monocrystalline cells
Max. Rated power P_max (STC)	425 Wp
Absorber Cu- tube	12 mm
Max. thermal power (890 W/m²)	975 W
Nominal volume flow	150 l/h

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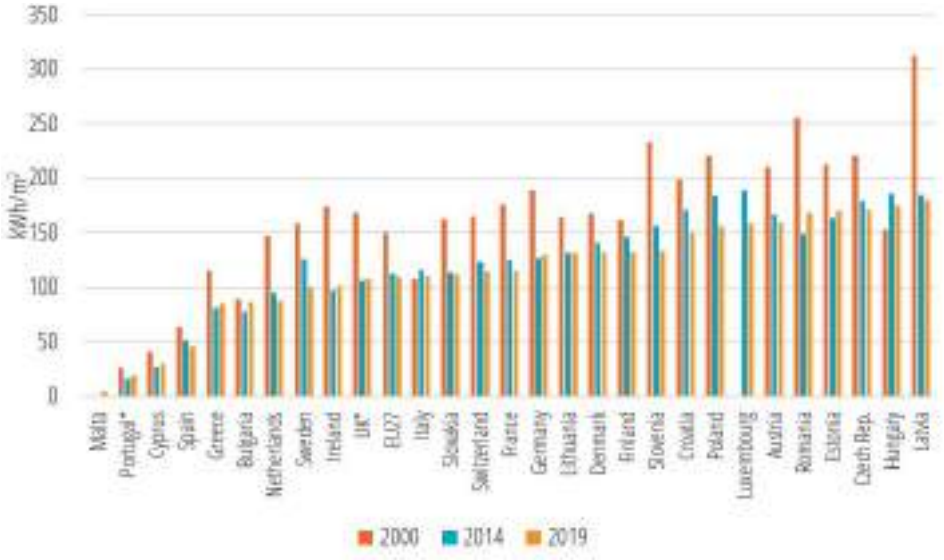
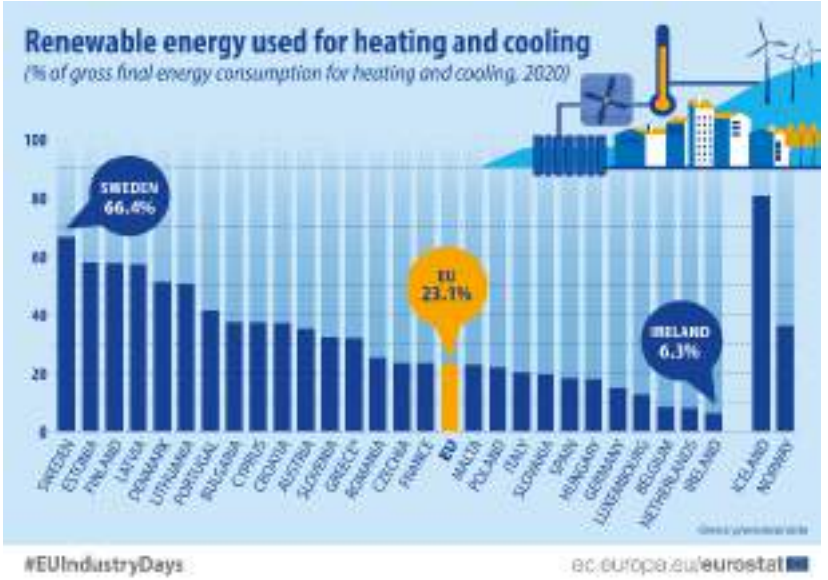
2. Energy demand in buildings

Status quo – thermal energy



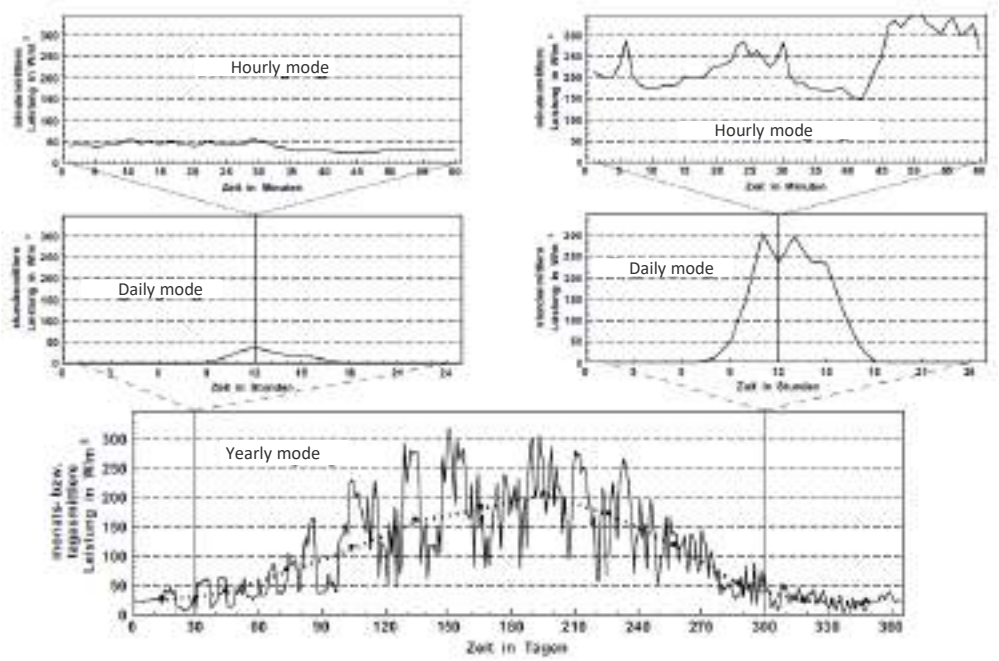


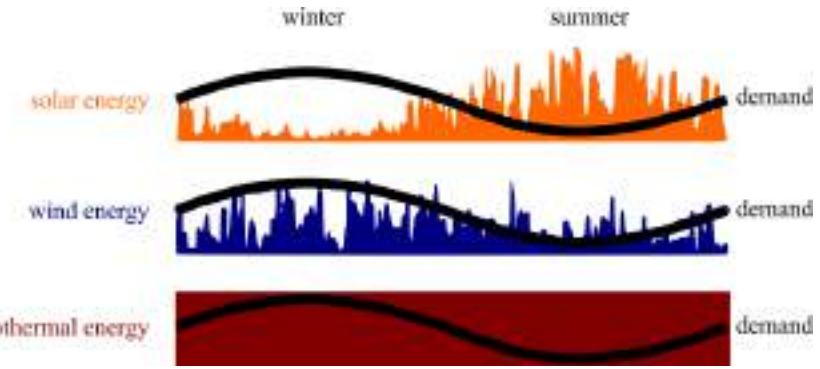
- Heating demand strongly dependent on local conditions → do Spaniards need to heat as much as Swedes?
- The share of renewables in Europe is much lower than for electricity → higher share of energy demand!

Source left: https://www.enerdata.net/publications/executive-briefing/households-energy-efficiency.html
Source right: https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20220126-1

Energy demand in buildings

Problem seasonality





Source right: Handbook on shallow geothermal energy; https://doi.org/10.1007/978-3-662-50307-2
Source left: Erneuerbare Energien; https://doi.org/10.1007/978-3-662-61190-6

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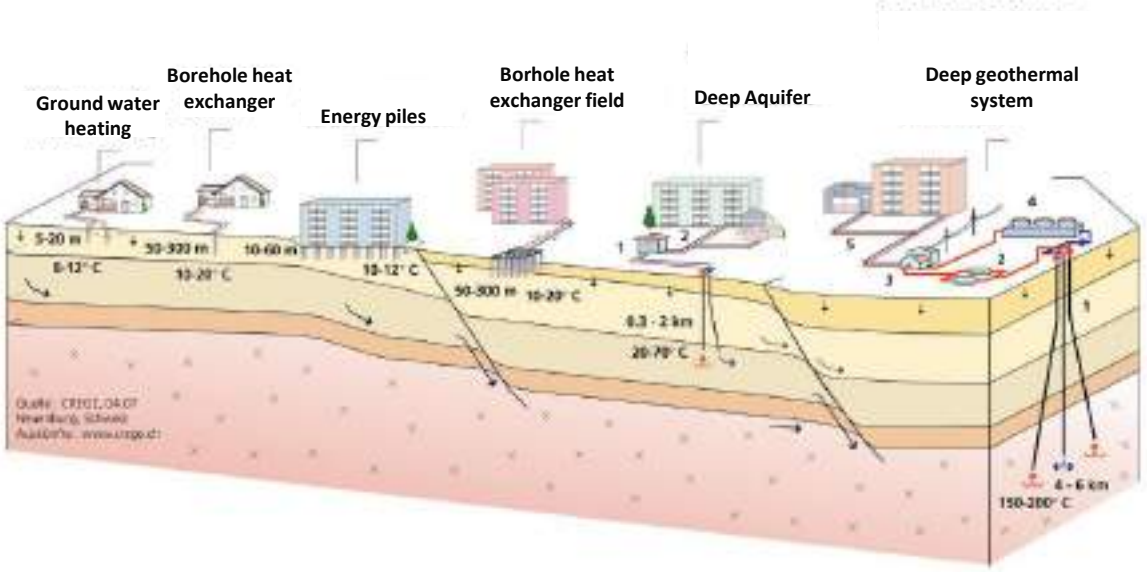
Geothermal


Ground water heating
Borehole heat exchanger
Energy piles
Borhole heat exchanger field
Deep Aquifer
Deep geothermal system
5-20 m
50-300 m
10-60 m
8-12° C
10-20° C
10-12° C
50-500 m
10-20° C
0.3 - 2 km
20-70° C
4 - 6 km
150-200° C

Use of geothermal energy

Geothermal systems for heating and cooling

Pro:
- constant temperature
- usable almost everywhere
- not visible, no noise
- cooling and heating

Con:
- low temperature
- expansive

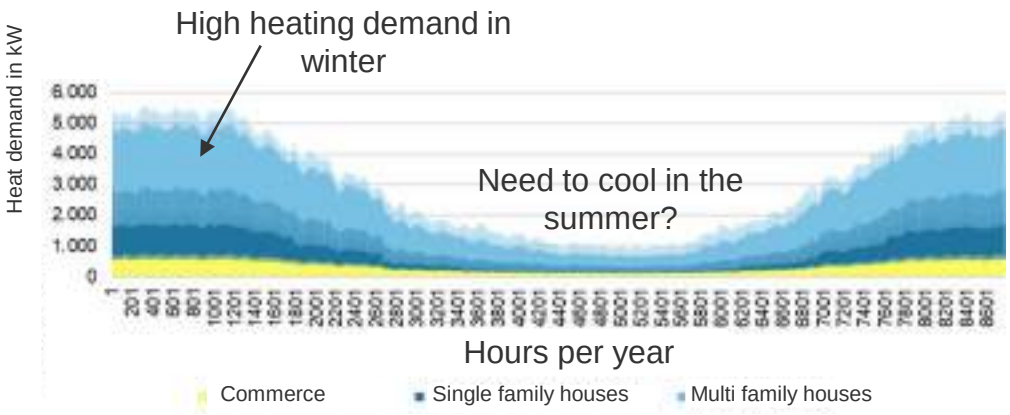
In general:
- Increasing temperature with depth (3K/100m)
- U-tube or double U-tube or coaxial tube
- 80-200m deep (for housholds)
- 12-15°C in 100m depth
- rule of thumb:
  ~40-60W/m depth or
  ~10-40W/m² collector

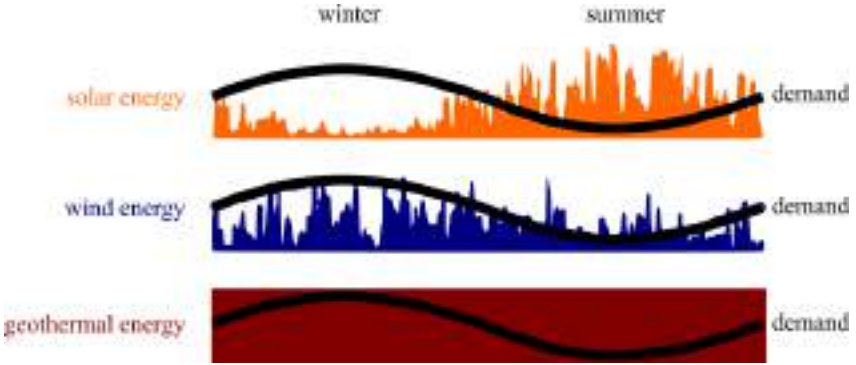
→ Heat Pump is needed for heating! (shallow)

https://www.waermepumpe.de/presse/mediengalerie/grafiken/.

Energy demand in buildings

Problem seasonality





- Seasonal demand: lots of heating in winter, possibly cooling in summer
- Also, renewable energy is often seasonal: for example, more sun in summer than in winter, the wind varies with the time of day and the season.

→ long term storing technologies needed

Source left: Final report project MareEn 2021-2022 TTD TUBAF
Source right: Handbook on shallow geothermal energy; https://doi.org/10.1007/978-3-662-50307-2

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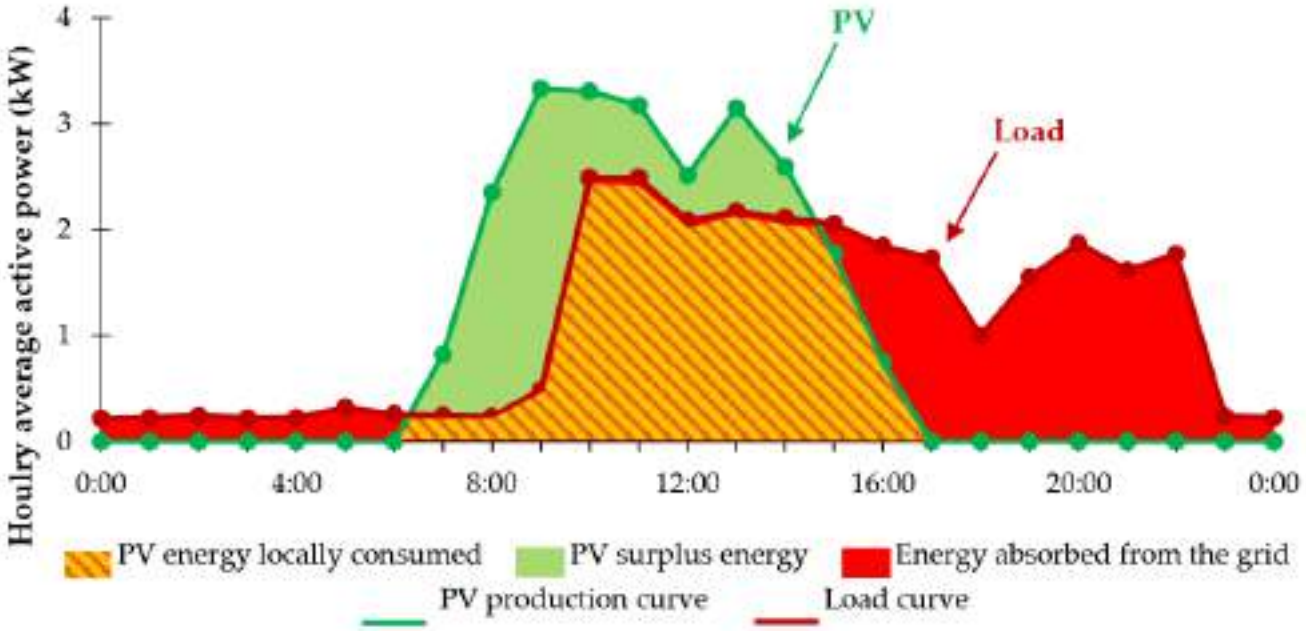
Storage technologies

Relevance: Households – electrical storage



3: Ciocia et al.: Self-Consumption and Self-Sufficiency in Photovoltaic Systems: Effect of Grid Limitation and Storage Installation2 (2021)

Storage technologies

Relevance: Households – electrical storage

- Inbalances on the household scale
  Production ↔ Consumption

➡ **Small-scale storage solutions necessary**

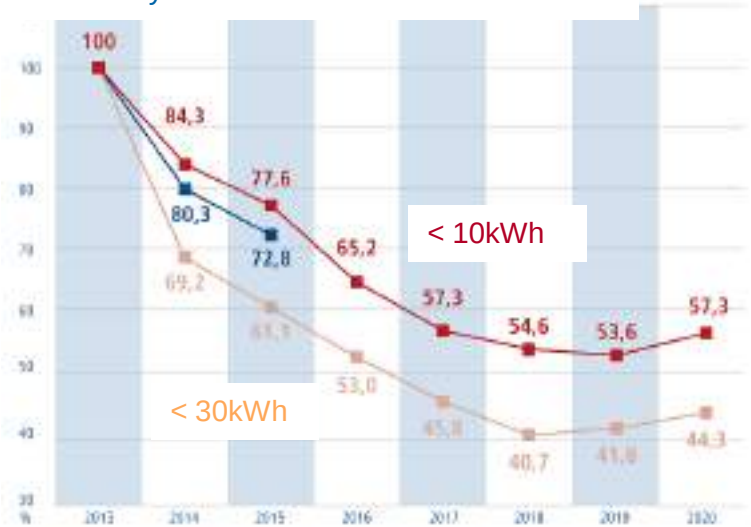
- Most common: Battery storage
- Self-sufficiency of ≈ 50-70% economically possible
- Obstacles:
  - Price → still decreasing with rising demand
  - Environmental issues → Research needed

4: Bagalini et al.: Solar PV-Battery-Electric Grid-Based Energy System for Residential Applications: System Configuration and Viability (2019)

Storage technologies

Relevance: Households – electrical storage

Development of prices for electrical storages in Germany



https://www.solaranlagen-portal.com/photovoltaik/stromspeicher/preise

E3DC

Solarwatt

Costs: 700-1000 EUR/kWh for Li storage in housholds

https://solarenergie.de/stromspeicher/preise

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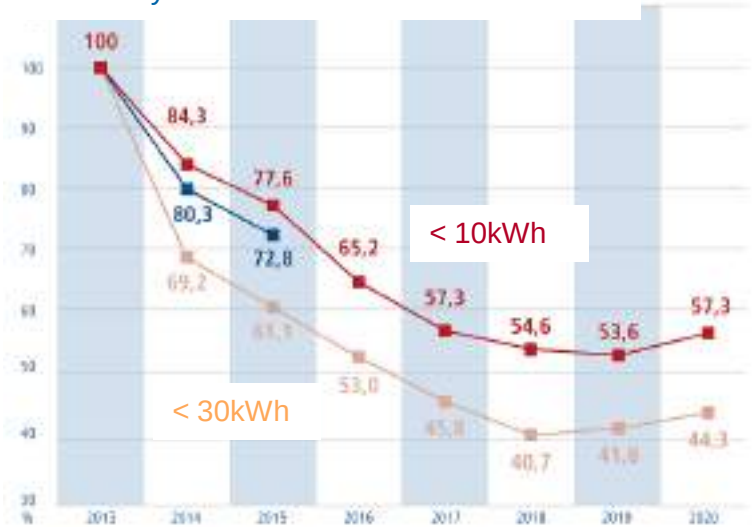
Storage technologies

Relevance: Households – electrical storage

Development of prices for electrical storages in Germany



https://www.solaranlagen-portal.com/photovoltaik/stromspeicher/preise

E3DC

Solarwatt

Example of calculation (rule of thumb):

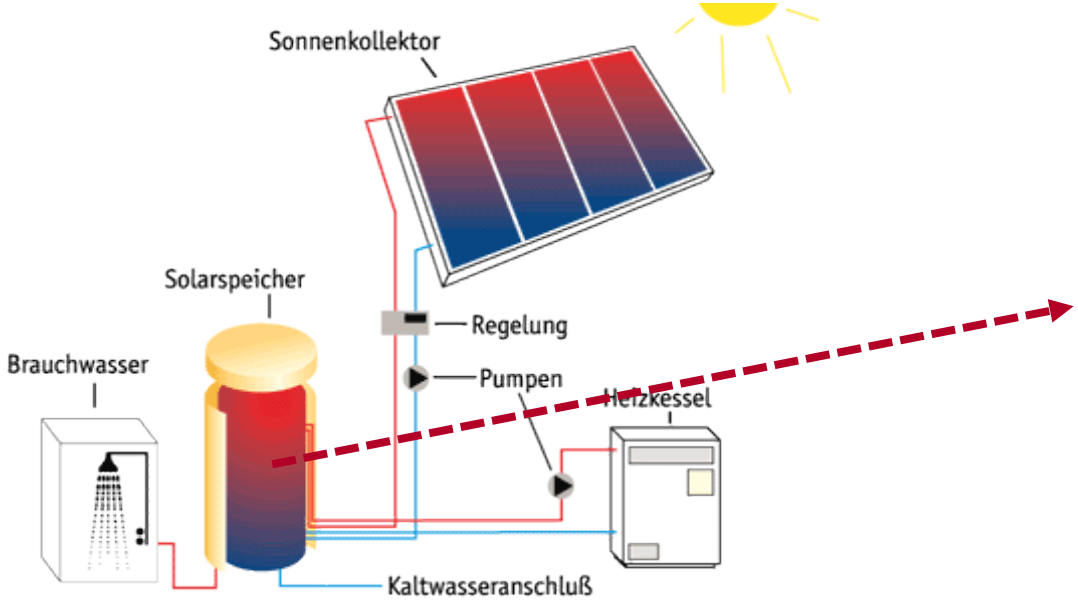
- Electricity consumption: 4,500 kilowatt hours (kWh)
- Main consumption: mornings and evenings (i.e. factor 0.5)
- Calculation: (4,500 kWh / 365 days) x 0.5 = 6.16 kWh

As a rule of thumb, the storage capacity (kilowatt hours) should correspond to 0.9 to 1.6 times the PV power (kilowatt peak).

https://www.net4energy.com/de-de/energie/pv-speicher-rechner

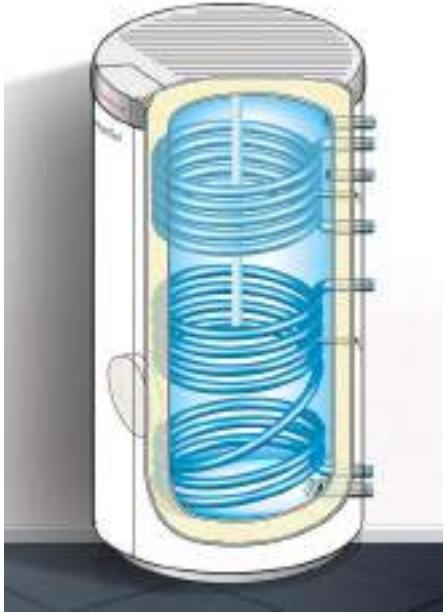
Storage technologies

Relevance: Households – thermal storage



https://www.leifiphysik.de/uebergreifend/energiespeicherung/grundwissen/speicherung-von-thermischer-energie

Layered storage



Viessmann VITOCELL 300-H

Hot (shower)

Warm (heating)

cold (backflow to collector)

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Storage technologies

Relevance: Households – thermal storage

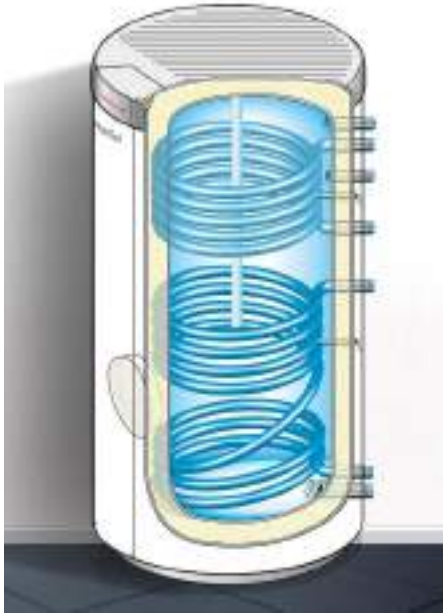
Rule of thumb: What volume do I need?

per person
- at least 60 to 80 litres of storage volume and
- 1 - 1.3 square metres of flat-plate collector area
- With vacuum tubes, the required collector area is lower at 0.8 - 1.0 square metres

Average sizes for a solar thermal system for water heating are therefore between 2.5 and 10 square metres of collector area and a storage tank size of 300 to 500 litres. → For house heating more

Rule of thumb!!!

Layered storage



Viessmann VITOCELL 300-H

Hot (shower)

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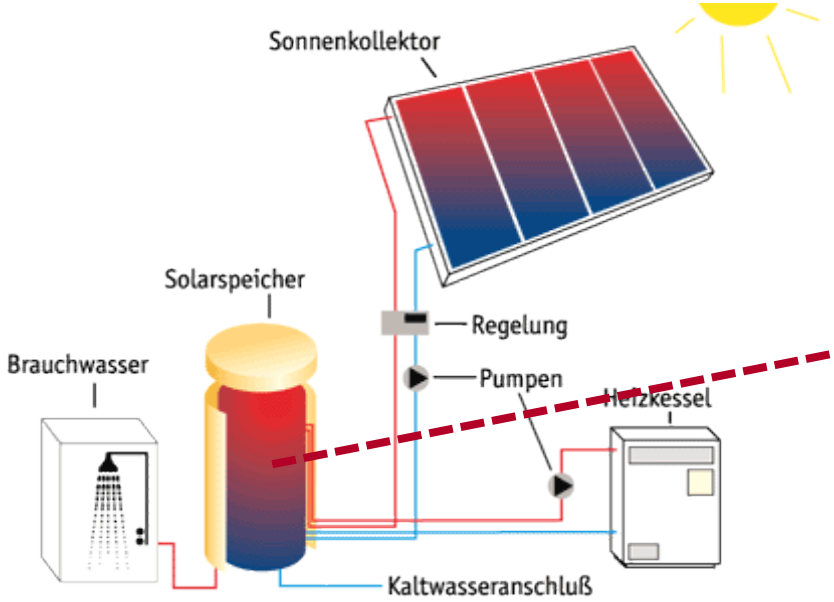
Storage technologies

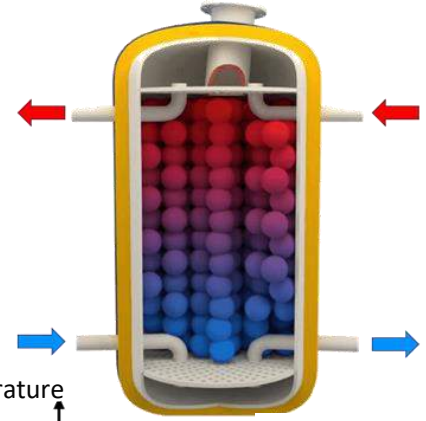
Relevance: Households – thermal storage



https://www.leifiphysik.de/uebergreifend/energiespeicherung/grundwissen/speicherung-von-thermischer-energie

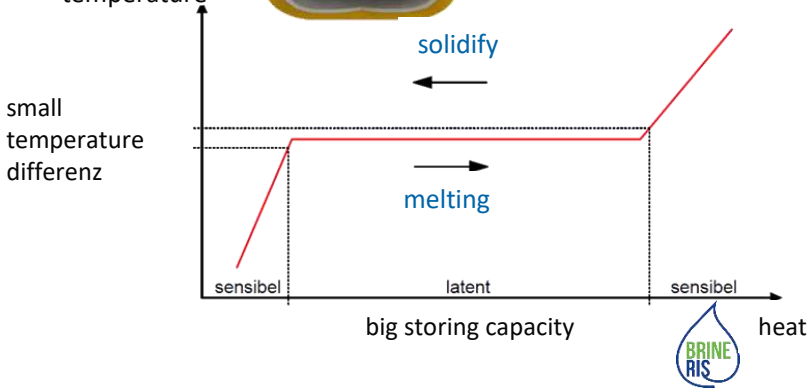
Latent storage

https://frigoteam.com/pcm-speicher/



Hot

cold (backflow to collector)



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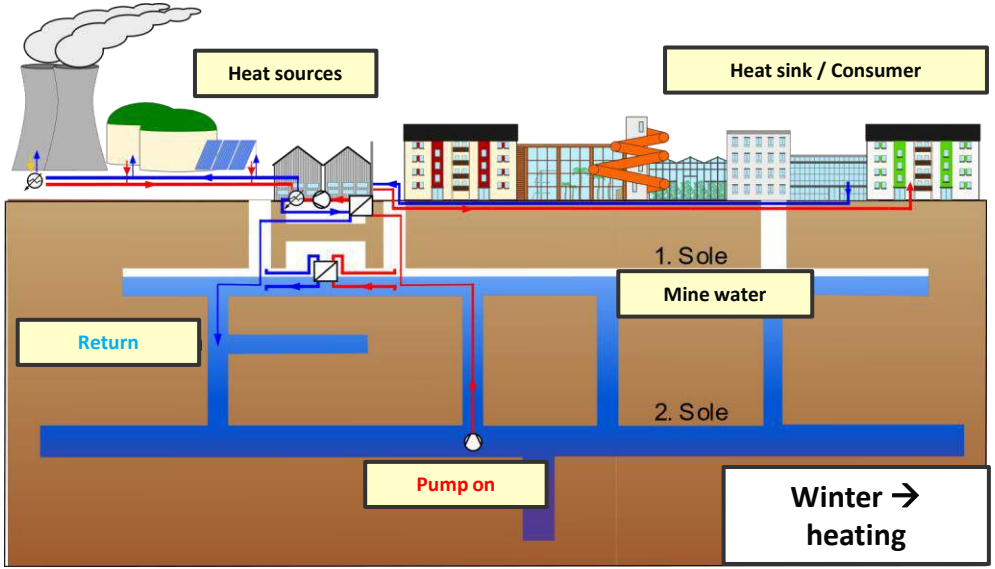
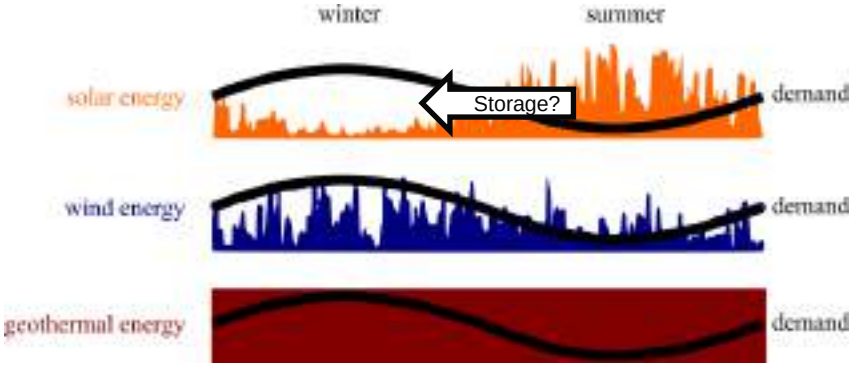
Saisonal storage technologies

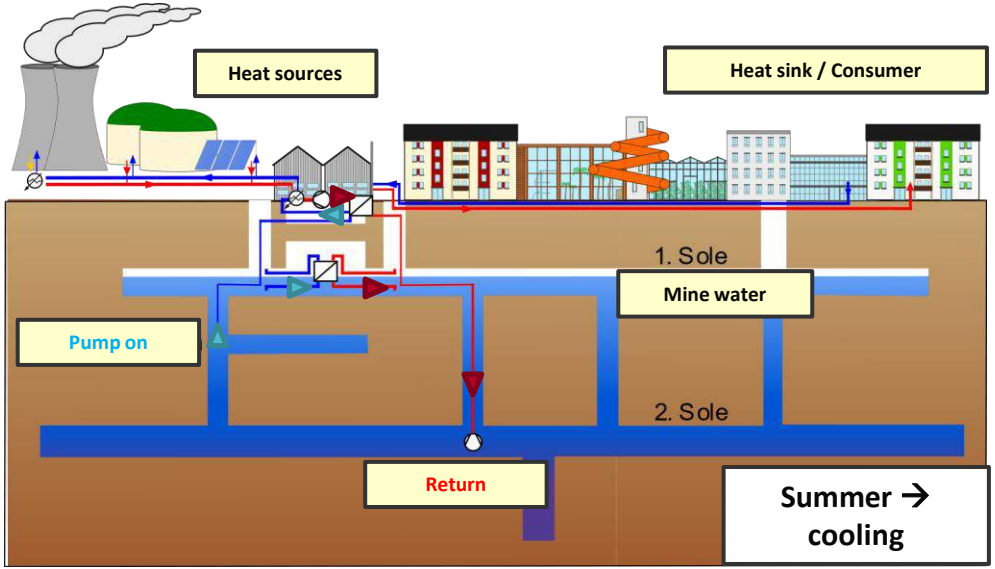
Storing energy in underground aquifers/mines/….

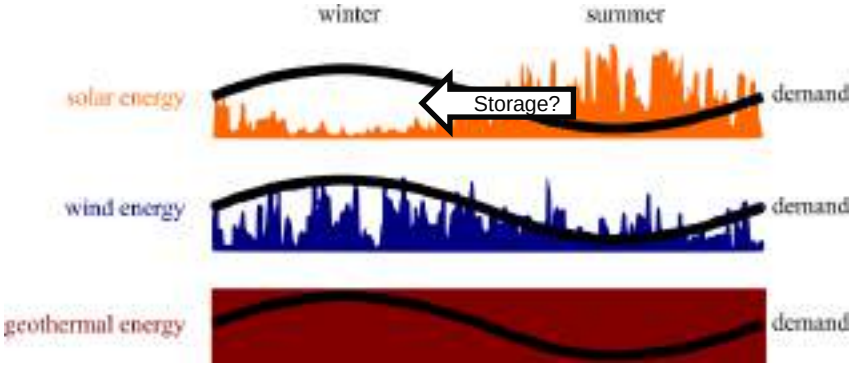




Saisonal storage technologies

Storing energy in underground aquifers/mines/….



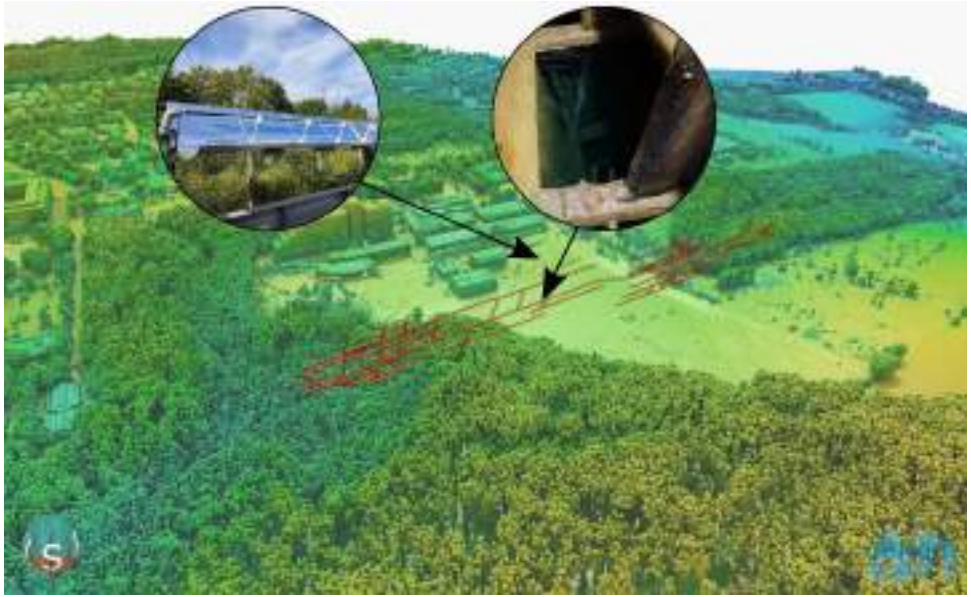


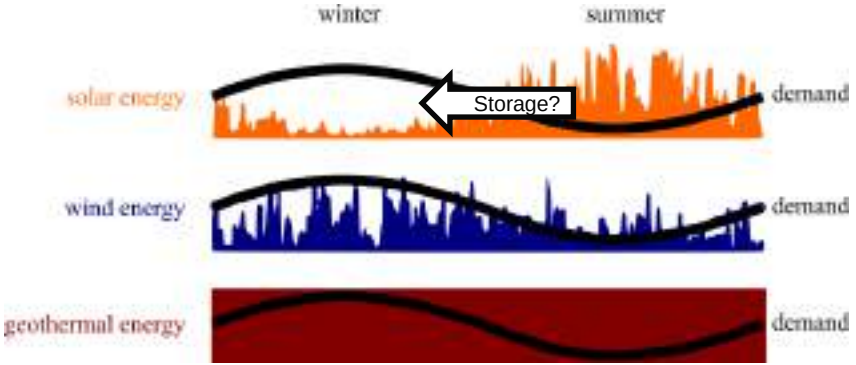
Important influencing factors:

- Porosity, flow velocity and heat capacity of the rock dependent
- Production and reinjection well necessary
- Examples: MTES, BTES, TTES, PTES

Saisonal storage technologies

Storing energy in underground mines → WINZER and MineATES project





Efficient operation for heat storages	Efficient heat exchangers for heat storages
WINZER	MineATES
2022-2025	2022-2025

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Thank you very much for your attention

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