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für Verkehr, Bau
und Stadtentwicklung

Geothermal Energy for Heating and Cooling of Buildings

Federal Ministry of Transport, Building and Urban Development
Unit B 12
Energy-efficiency, energy saving and renewable energies in the building sector

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Outlook

- Reasons to increase the use of renewable energies e.g. geothermic energy by heat pumps
- Samples, pilot projects (technical data and experiences):
  - Single-family house
  - Refurbished “Reichstags”-building Berlin
- Outlook – new Building Standards with renewable energies

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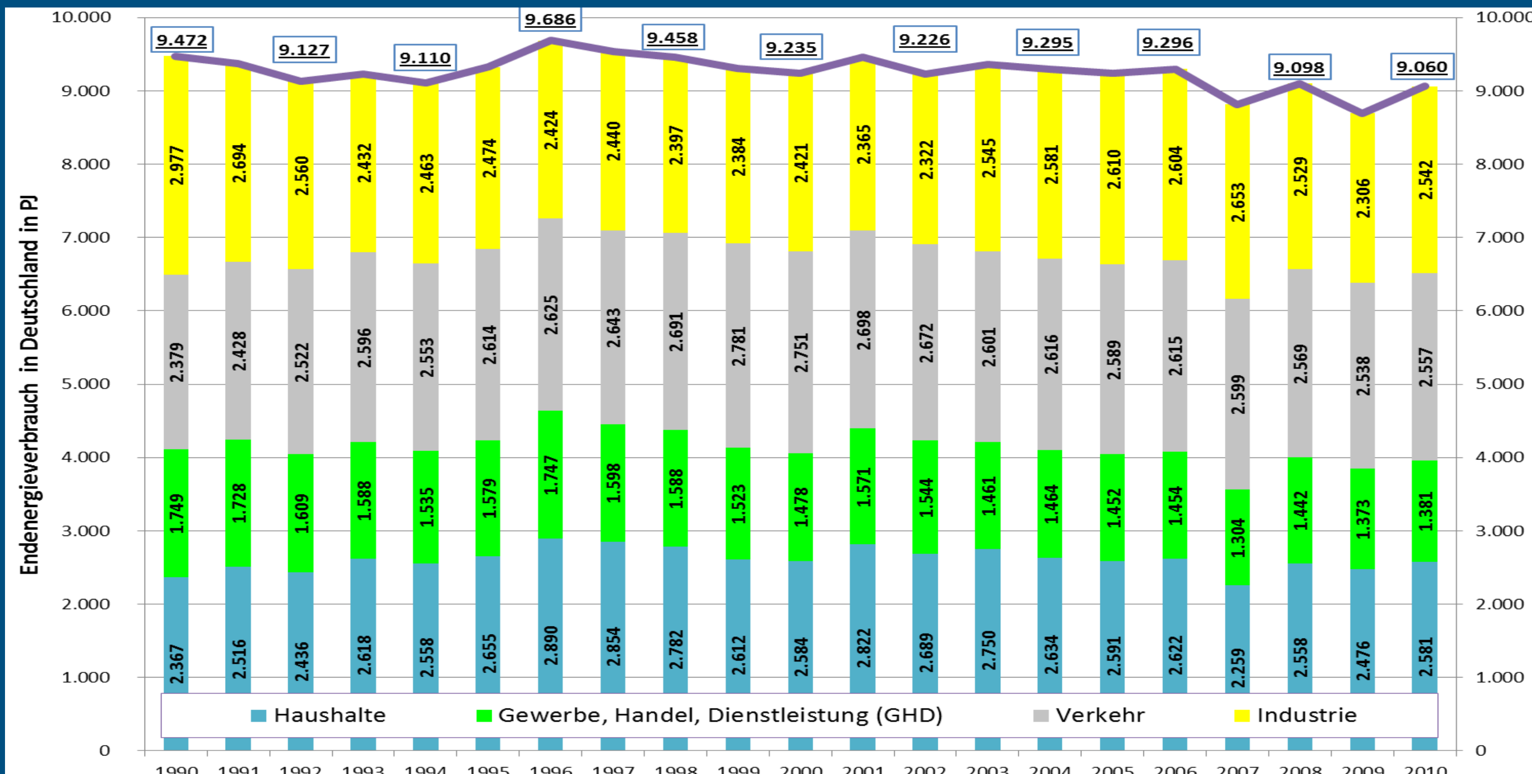
Energy consumption in Germany

Trend of final energy consumption



ca.
40 %
buildings

Entwicklung des Endenergieverbrauchs in Deutschland nach Sektoren seit 1990; Quelle: AGEB

En bleu et en vert : le secteur du bâtiment

www.bmvbs.de

source: BMWi

European framework:

security of energy supply

- reducing demand of energy
- saving energy
- more energy efficiency and renewables

economic efficiency, competitiveness

- reducing energy costs
- economic measures for more energy efficiency
- decreasing energy demand especially for existing buildings

sustainability, climate protection

- Kyoto Protocol/ follow-up agreement
- climate change, global warming, ghg emissions
………

European obligation

DIRECTIVE 2010/31/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 19 May 2010 on the energy performance of buildings (recast) – (guidelines for all MS)
more: www.buildup.eu

Implementation in Germany: “Energy Saving Order” (EnEV)
Requirements for new and existing buildings (e.g. refurbishments, energy certificates)

EPDB - covered scopes e.g.:

heating systems

insulation, energetic quality of building envelope

hot water supply

air conditioning systems

ventilation

energy certificates

illumination

renewable energies e.g. geothermal energy

EPBD

Article 2

Definitions

For the purpose of this Directive, the following definitions shall apply:

…

2. ‘nearly zero-energy building’ means a building that has a very high energy performance, …The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby;

EPBD

Article 9

Nearly zero-energy buildings

1. Member States shall ensure that:

(a) by 31 December 2020, all new buildings are nearly zero- energy buildings; and

(b) after 31 December 2018, new buildings occupied and owned by public authorities are nearly zero-energy buildings.

Member States shall draw up national plans for increasing the number of nearly zero-energy buildings. These national plans may include targets differentiated according to the category of building.

Strategies to increase renewables and energy efficiency e.g.

Law
Energy Saving Order (EnEV) – Energy Certificates, requirements for buildings

Financial benefits
promotion by e.g. KfW-Federal Bank – additional BAFA for renewable energies

Information, transparency in the market, best practice projects
promoting Energy Certificates, PR

Research
program for research in the building sector – ca. 9 Mio. €/a

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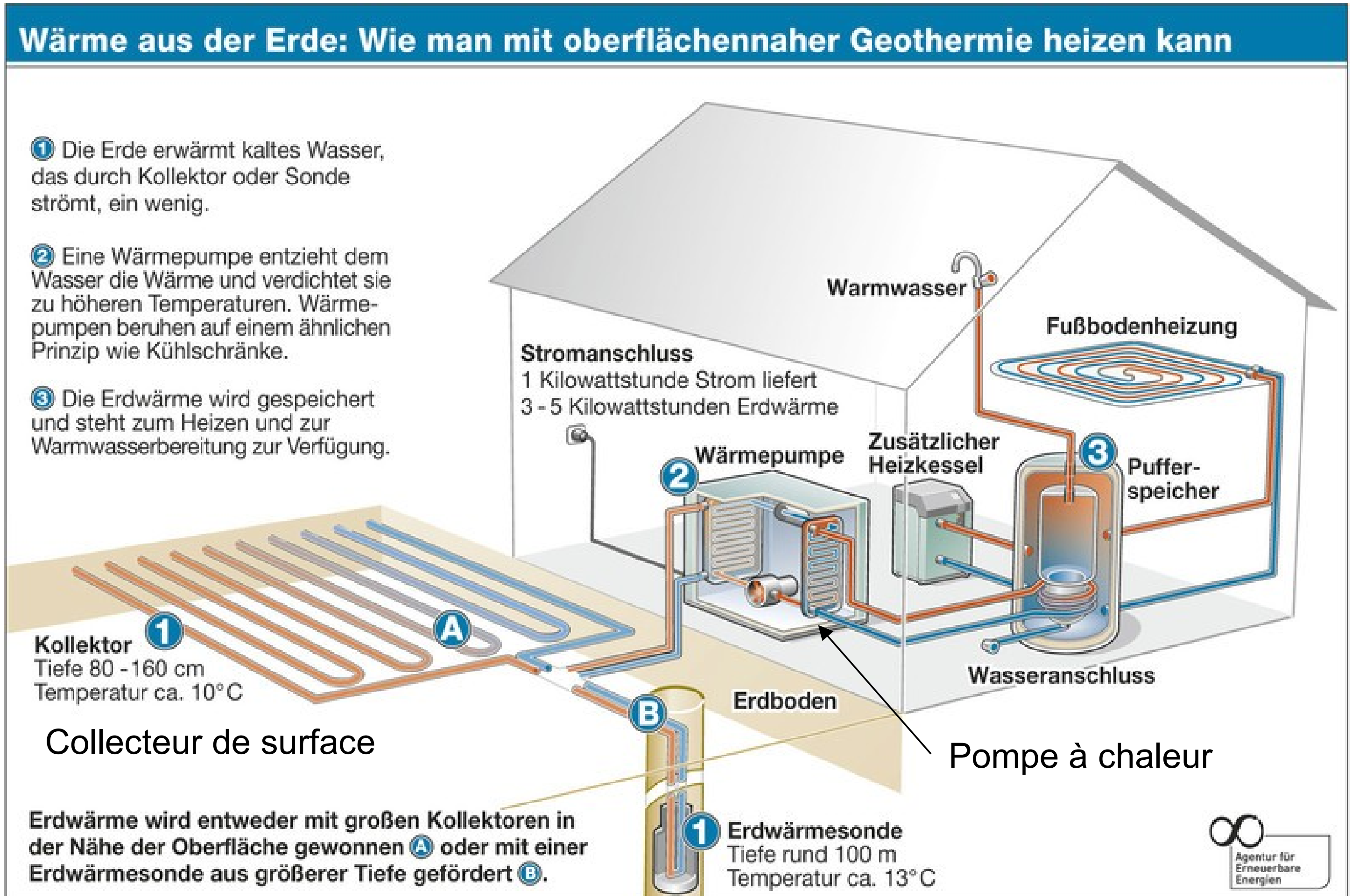
Samples:

Near surface geothermal energy used by heat-pump system

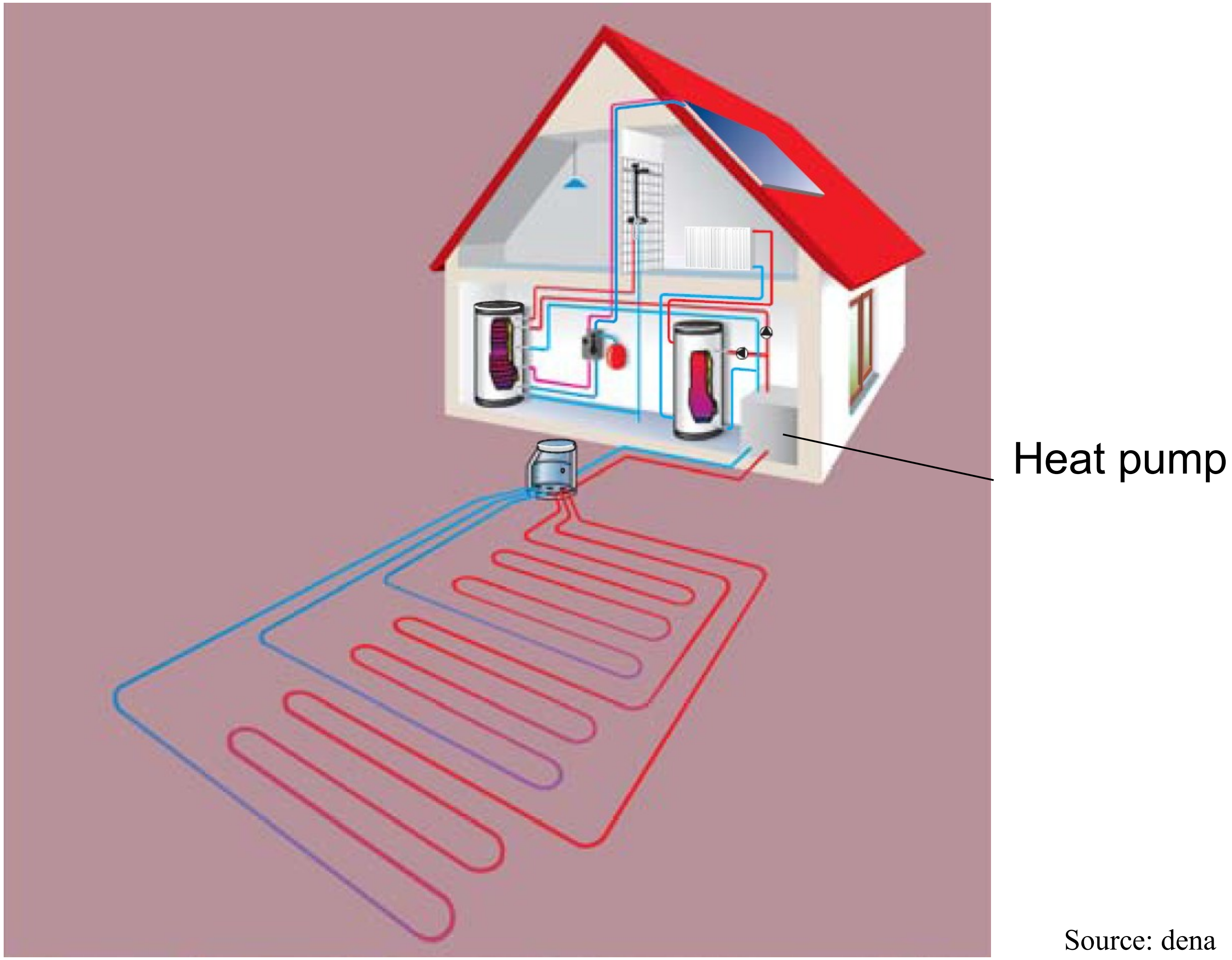


Source: dena

Sonde géothermique
verticale profonde

Sample single Family house:

Near surface geothermal energy used by heat-pump system



Source: dena

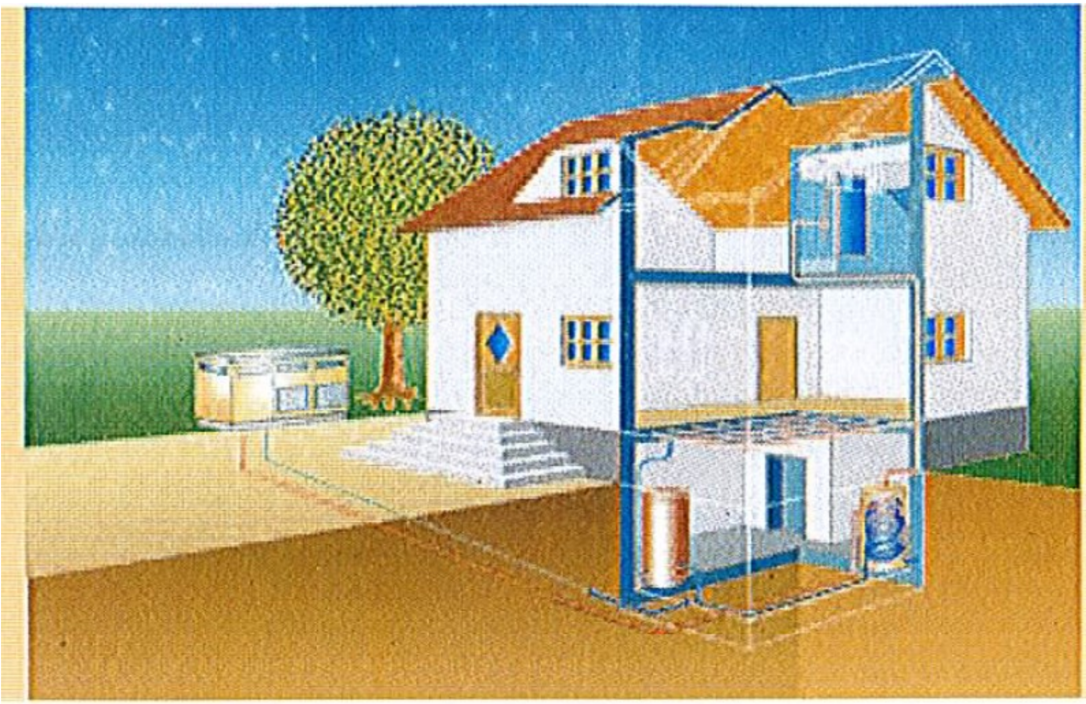


Abb. 23 *Schema einer Luft/Wasser-Wärmepumpe*
Quelle: Abb. 23 – 24 Bundesverband Wärmepumpe e. V., Berlin

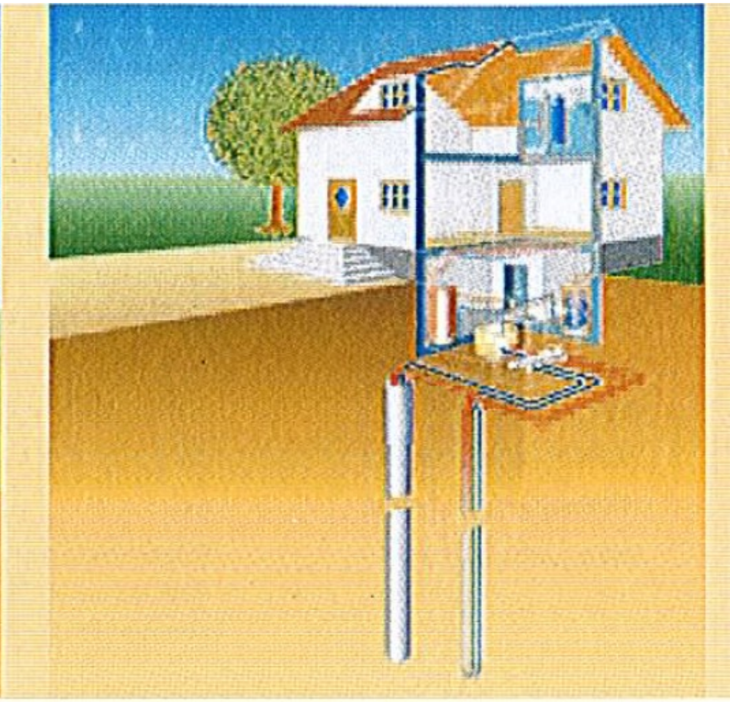


Abb. 24 *Schema einer Erdreich/Wasser-Wärmepumpe*

Source: BINE

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Sceme technical Appliances:
Combined geothermal and solar energy use

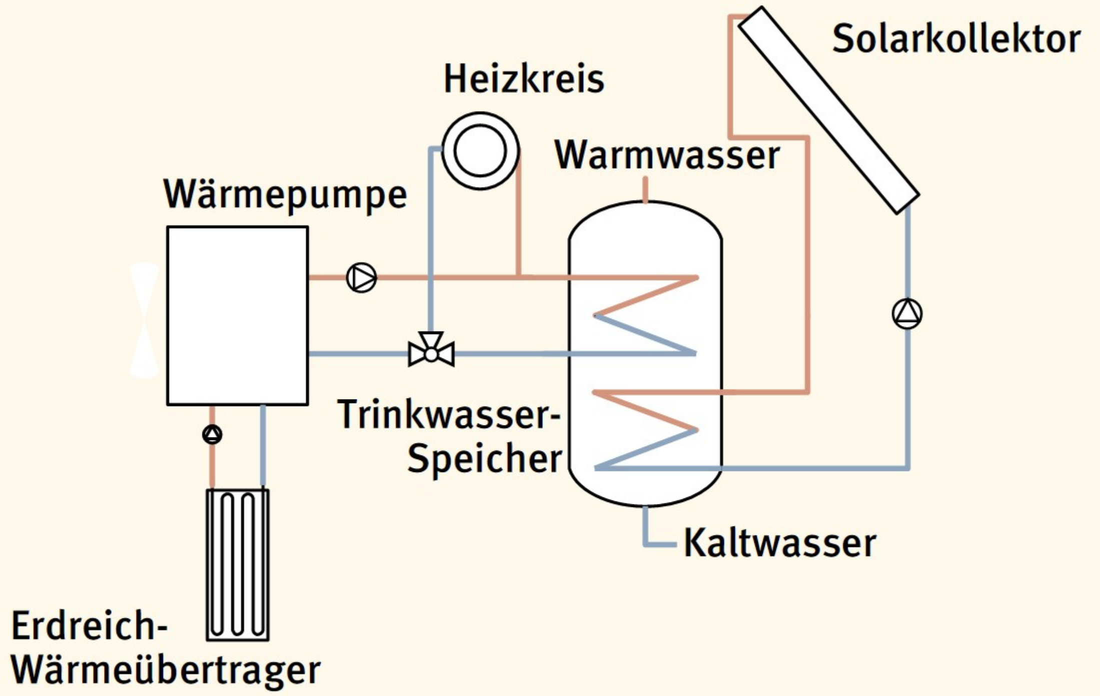

Abb. 37 *Anlagenschema eines Wärmepumpensystems mit Einbindung eines Flachkollektors an den Trinkwasserspeicher.*

Source: BINE

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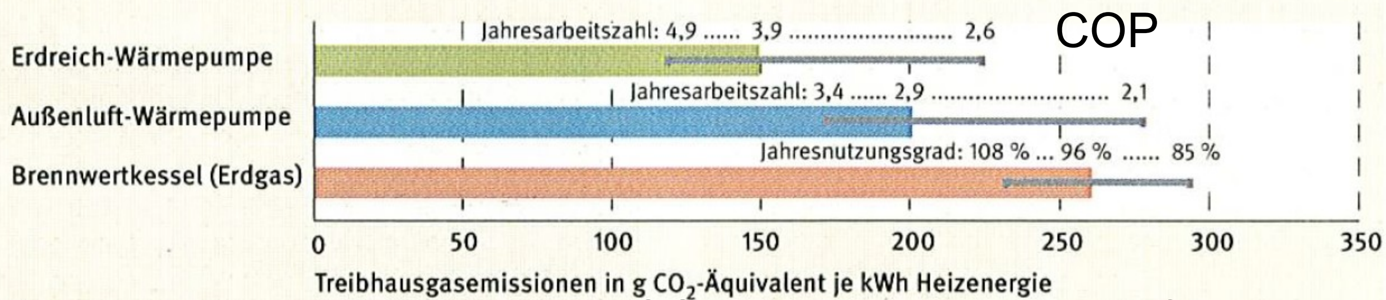
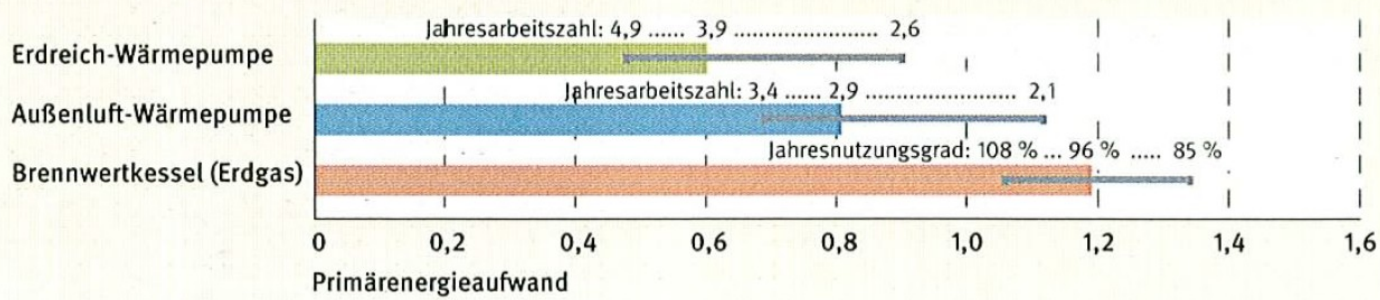
Coefficient of power – COP
Greenhousegas-Emissions

En vert : Pompe à chaleur géothermique (eau eau)
En bleu : Pompe à chaleur air (air eau)
En rouge : Chaudière à condensation (gaz)

Abb. 11 *Treibhausgasemissionen (ohne Berücksichtigung von Kältemittelverlusten) sowie Primärenergieaufwand von Wärmepumpen und Gas-Brennwertkesseln. Quelle: FhG-ISE*



Emissions g CO2 pour 1kWh énergie finale



Energie primaire consommé pour obtenir 1kwh

Source: BINE

Sample:

Heat source outside air energy used by heat-pump system

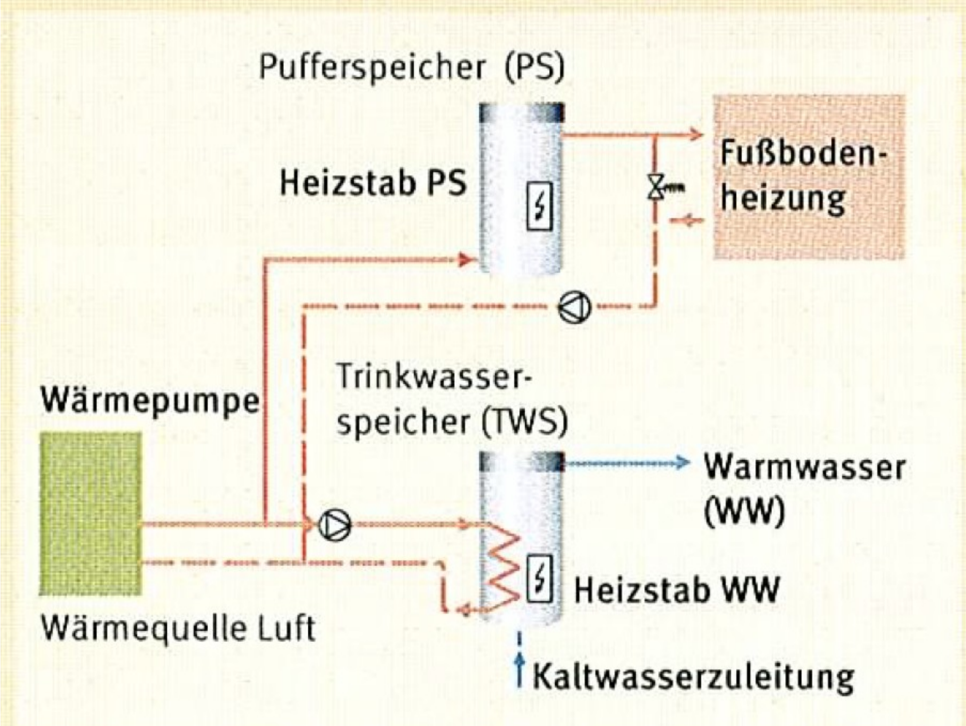


Abb. 6 *Anlagenschema. Quelle: FhG-ISE*

Steckbrief Einfamilienhaus

Gebäudetyp	Einfamilienhaus
Bau- und Installationsjahr	2010
beheizte Gebäudefläche	127 m²
energetische Gebäudeklasse	Niedrigenergiehaus
Wärmepumpentyp	elektrisch betriebene Wärmepumpe
Heizleistung	7,5 kW (bei A2/W35 nach EN14511)
COP	3,7 (bei A2/W35 nach EN14511)
Kältemittel	R404A
Einsatzbereich	Heizung und Warmwasser
Wärmequellensystem	Außenluft – außen aufgestellt
Speicher	Pufferspeicher 200 l Trinkwasserspeicher 300 l
Wärmeverteilsystem	Fußboden-, Wandheizung, Handtuch-Radiatoren
Auslegungsheizkreistemperatur	Vorlauf: 38 °C / Rücklauf: 33 °C
Betriebsart	monoenergetisch

Abb. 5 *Quelle: FhG-ISE*

Measured COP = 3,3 (from May 2010 to April 2011)

Source: BINE

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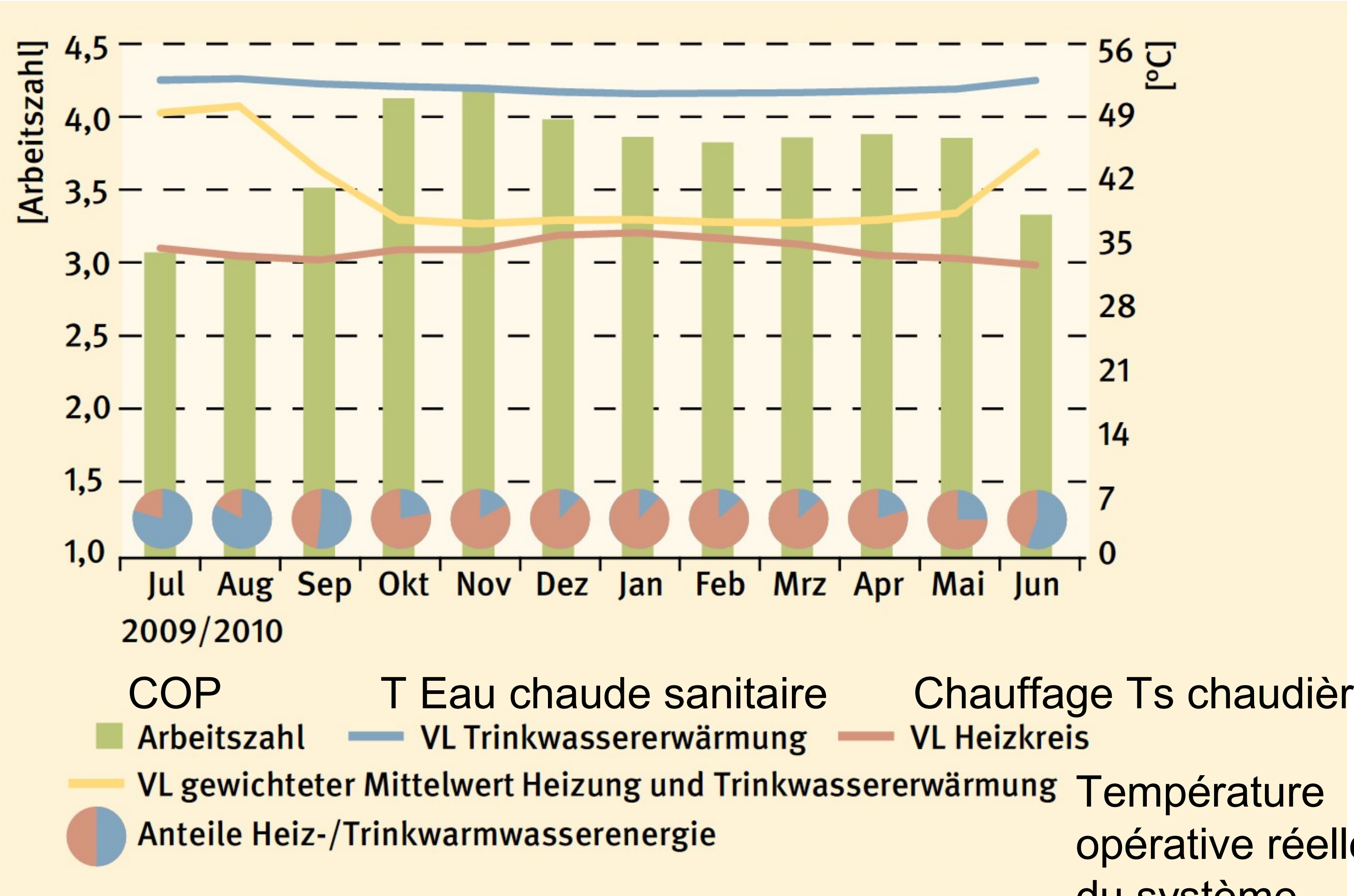
Coefficient of power – COP
Heat-pump: Energy source - ground soil

COP



COP

T Eau chaude sanitaire

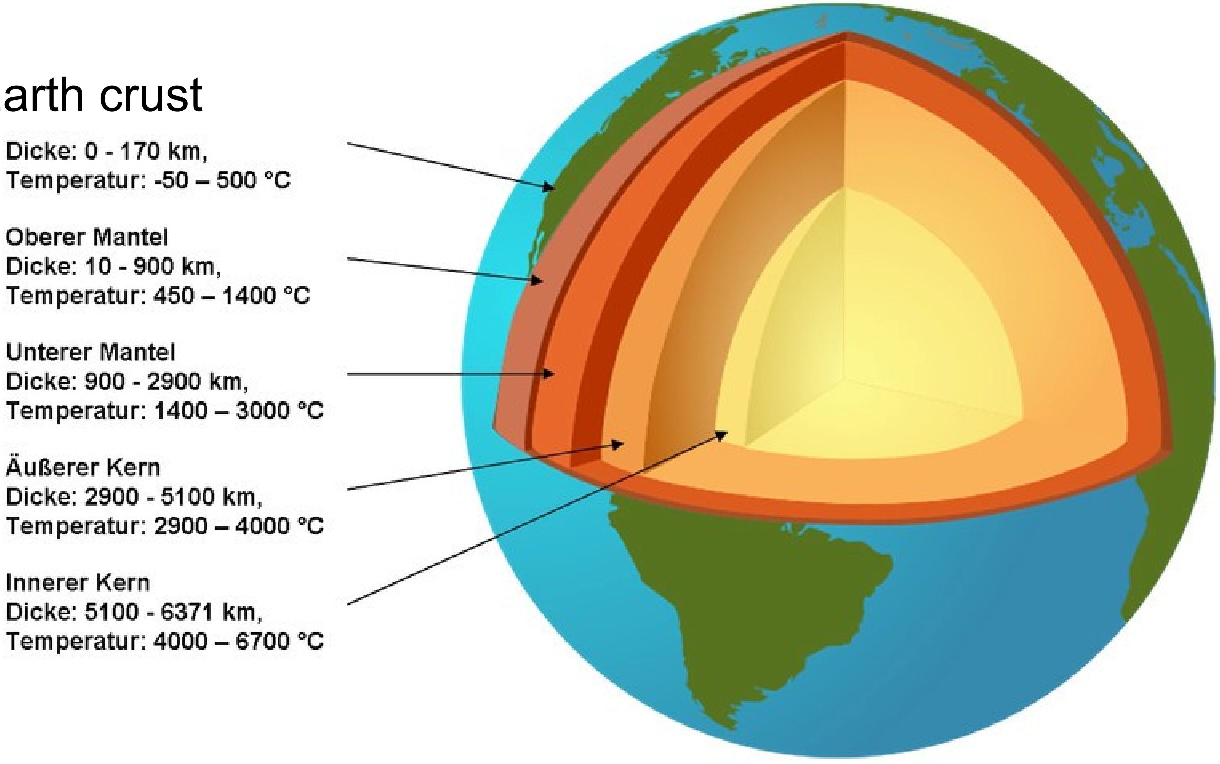
Chauffage Ts chaudière

Température opérative réelle du système

Source: BINE

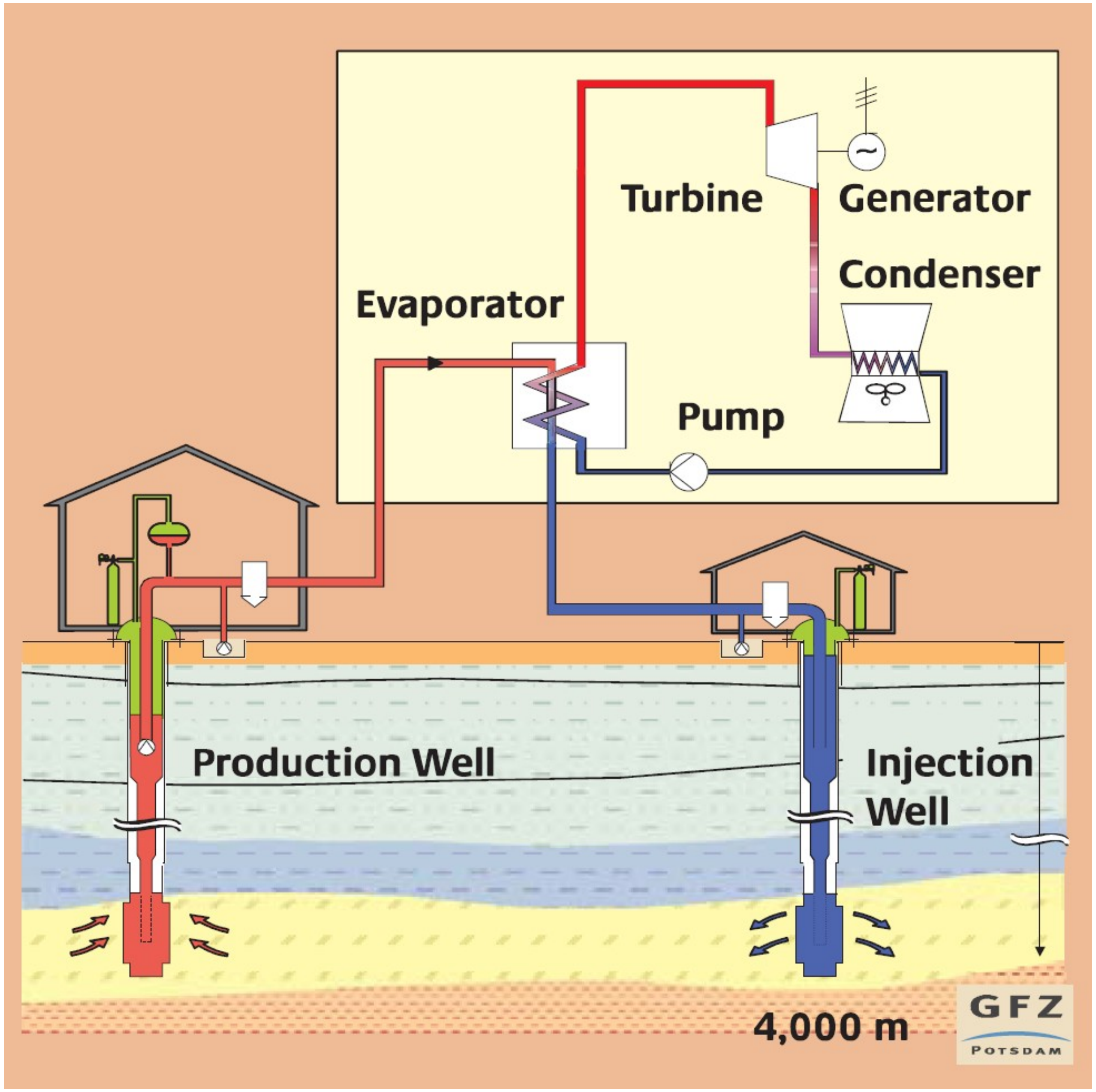
Geothermical temperature potential

Earth crust



Source: GfZ

Principles and samples for Deep geothermal energy use and storage



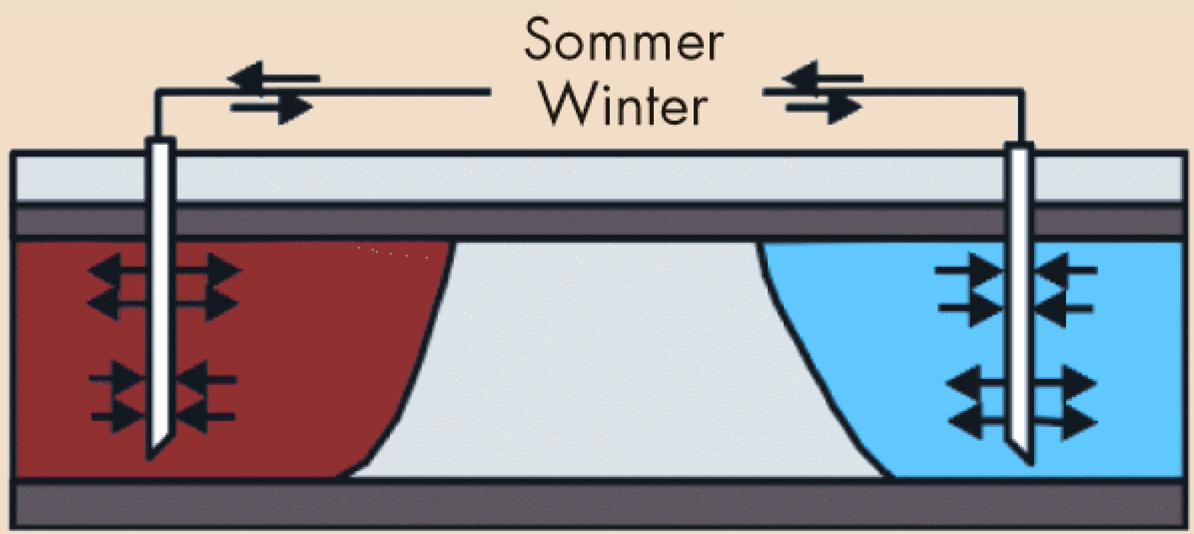
Source GFZ

BT

Reichstag building Berlin: Construction work

Source: BINE

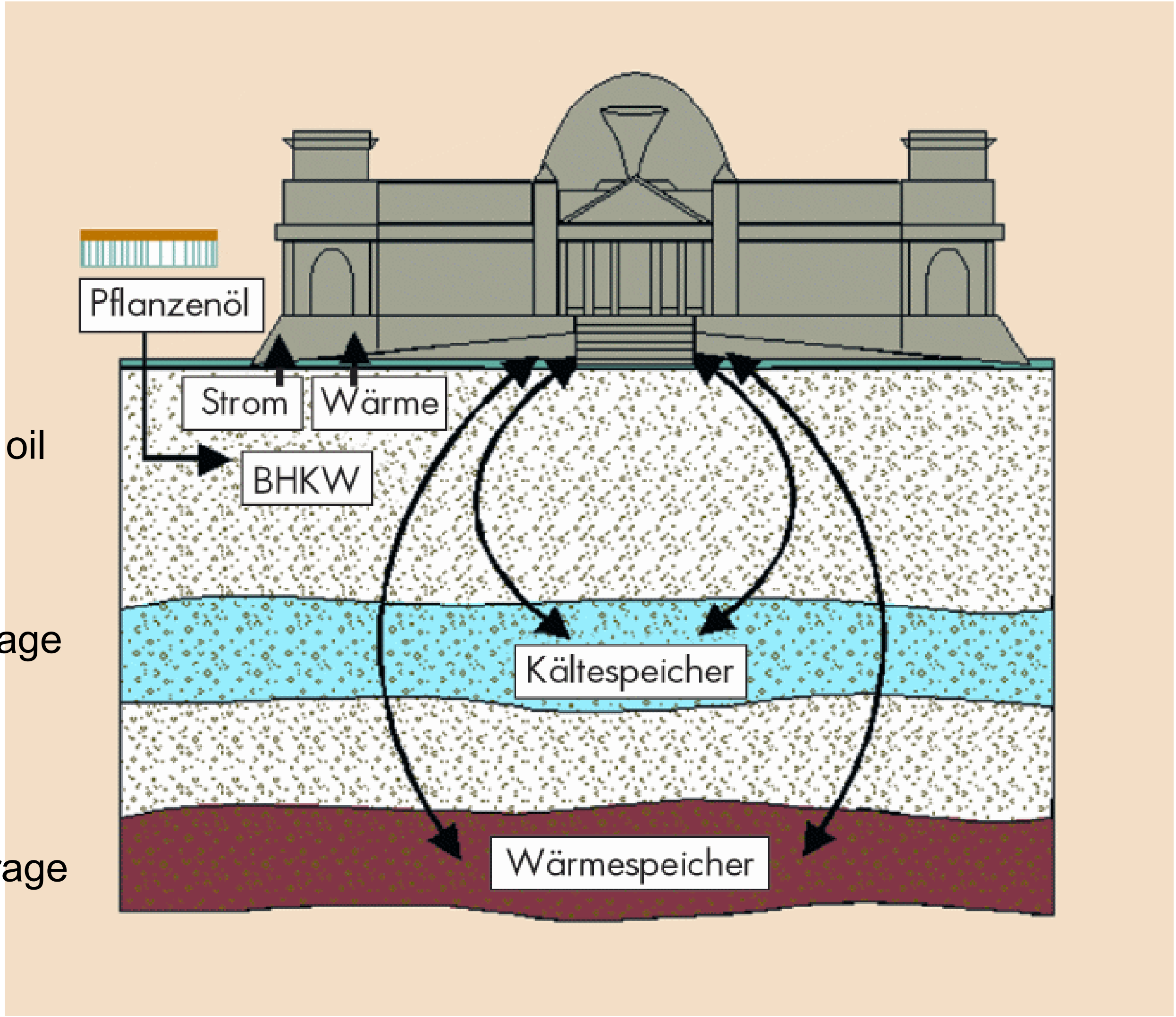
Seasonal energy storage e.g.
by combined heat and power unit (chp), solar system etc



Demande d’énergie pour tous les bâtiments connectés

Energiebedarf des Gebäudeensembles		
Strom électricité	8.600 kW	19.500 MWh/a
Wärme	12.500 kW	16.000 MWh/a
Kälte	6.200 kW	2.800 MWh/a

Source: BINE



CHP by vegetable oil

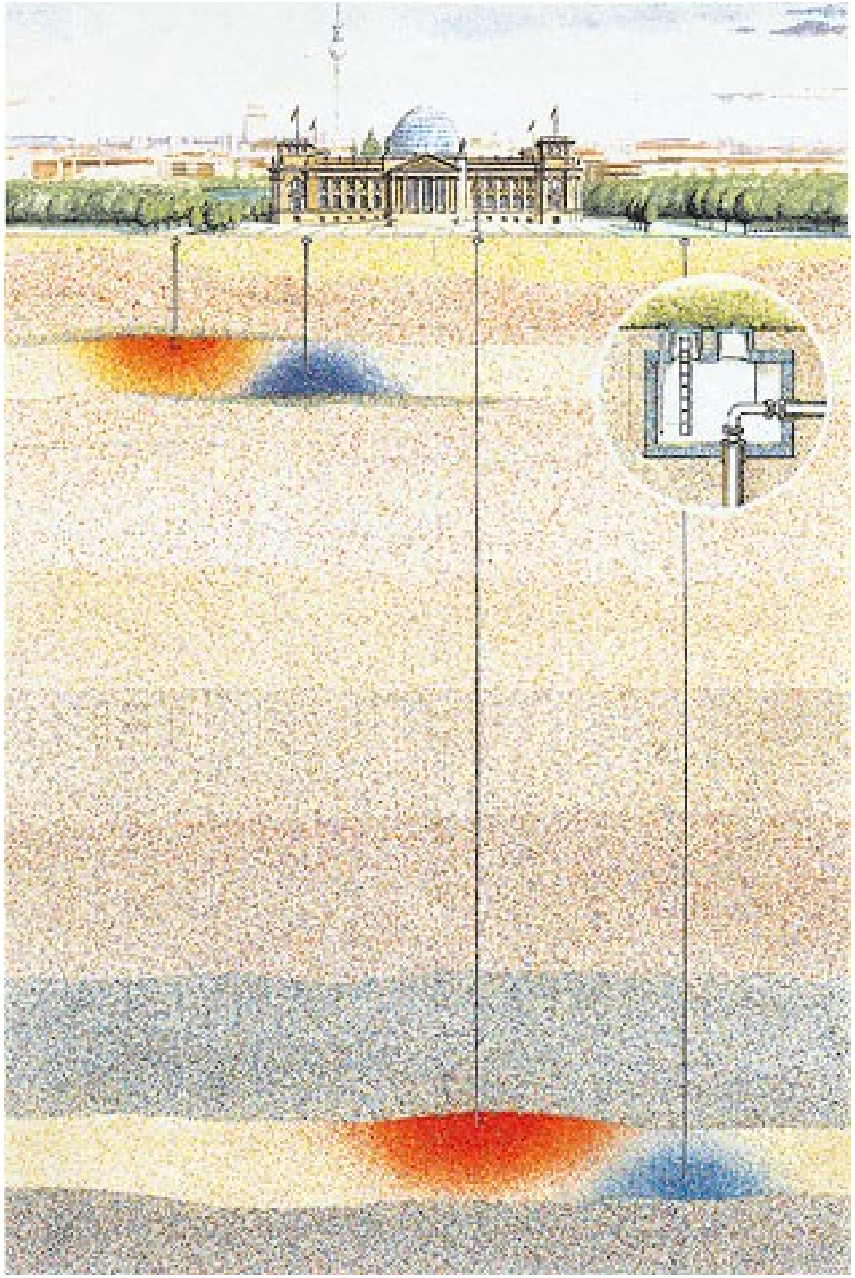
Coldness storage

Heat storage

Source: BINE

coldness storage

heat storage



Source: BT

Reichstag building Berlin: Heat storage

Kenndaten			
Sommer (Beladung)	mittlere Fördertemperatur	20°C	Summer
	Injektionstemperatur	70°C	
	eingelagerte Wärme	2.650 MWh/a	
Winter (Entladung)	Fördertemperatur	65-30°C	Winter
	entnommene Wärme	2.050 MWh/a	
Bilanz	Förderaufwand	280 MWh	
	Verhältnis genutzter zu eingelagerter Wärme	77%	

* Kenndatenermittlung auf Basis dynamischer Simulationsrechnung

efficiency factor 77%!

Source: BINE

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Reichstag building Berlin: Coldness storage

Kenndaten

Sommer (Entladung)	Fördertemperatur	6-10°C	Summer
	Injektionstemperatur	15-28°C	
	entnommene Kälte	3.950 MWh/a	
Winter (Beladung)	Mittlere Fördertemperatur	22°C	Winter
	Injektionstemperatur	5°C	
	eingelagerte Kälte	4.250 MWh/a	
Bilanz	Förderaufwand	220 MWh	
	Verhältnis genutzter zu eingelagerter Kälte	93%	

* Kenndatenermittlung auf Basis dynamischer Simulationsrechnung: Temperaturveränderungen während des Entladezyklus sind berücksichtigt. Das System befindet sich noch nicht in „eingeschwungenem Zustand“.

efficiency factor 93%!

Source: BINE

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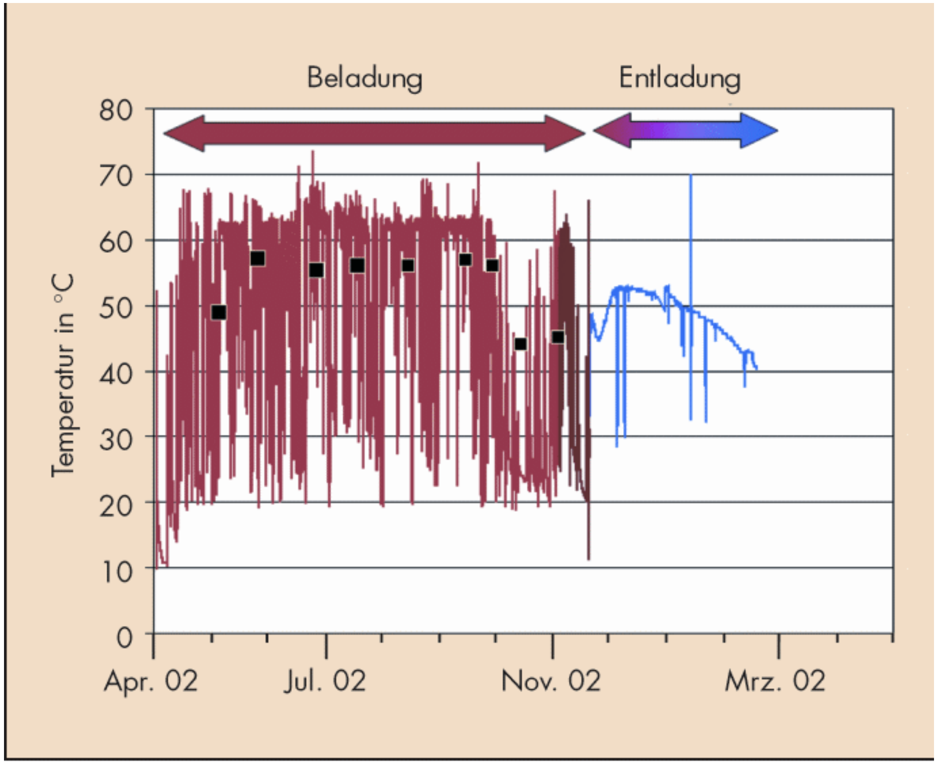

Abb 7: Investitionskosten für realisierte Wärmespeicher-Konstruktionen (volumenbezogen; inkl. Planung, ohne MwSt.)

Aquiferspeicher	Betonspeicher	Stahltanks	GFK-Speicher
bis zu 25 Euro/m³ (bei Volumina von 100.000 m³)	450 - 120 Euro/m³ (abhängig vom Speichervolumen)	3.000 - 600 Euro/m³ (Angabe für 0,2 bis 100 m³); bei Großspeichern (10.000 m³) unter 100 Euro/m³	432* - 125 Euro/m³ (abhängig vom Speichervolumen) *Neue Fertigungs-technologie: ab 300 m³

Source: BINE

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ENERGIEAUSWEIS für Nichtwohngebäude

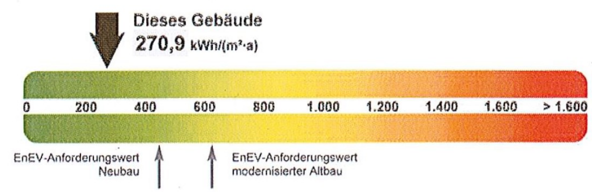
gemäß den §§ 16 ff. Energieeinsparverordnung (EnEV)

Gültig bis: 14.06.2019 — **Aushang**

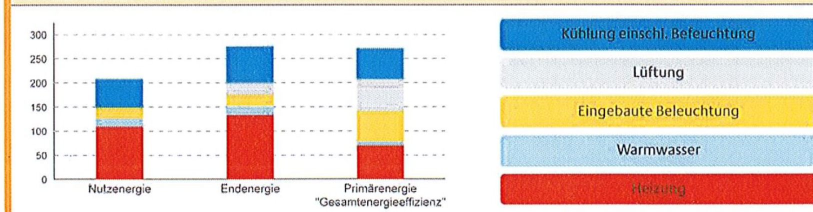
Gebäude

Hauptnutzung/ Gebäudekategorie	Deutscher Bundestag / Parlamentsgebäude
Sonderzone(n)	
Adresse	Platz der Republik 1, 11011 Berlin
Gebäudeteil	Reichstagsgebäude
Baujahr Gebäude	1894
Baujahr Wärmeerzeuger	1998
Baujahr Klimaanlage	1998
Nettogrundfläche	40.047 m²

Primärenergiebedarf „Gesamtenergieeffizienz“



Aufteilung Energiebedarf



Aussteller

Fraunhofer IBP

Mega:WATT

15.06.2009 gez. Böttcher gez. Erhorn gez. Schröter

Datum — Unterschrift des Ausstellers

Source: BT

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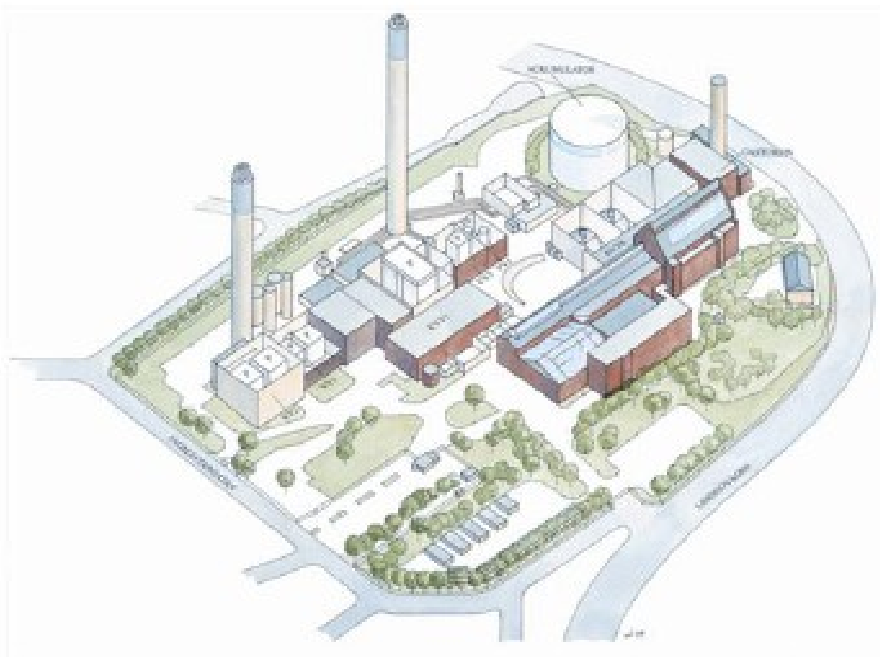
BMVBS

Sea water energy generation

The Värtan Trigeneration Plant



NIMROD

Maximum capacity

•CHP ("KVV 6")	145 MW el / 310MW heat
• Biooil fired CHP	190 MW el / 320 MW heat
• Heat pumps/ chillers	275 MW heat/ 150 MW cooling
• Peak load boilers	620 MW heat
• Electric boilers	230 MW heat
• Gas turbine 3	54 MW el
• Accumulator	40 000 m^3 / 2 000 MWh

Energy production/2009

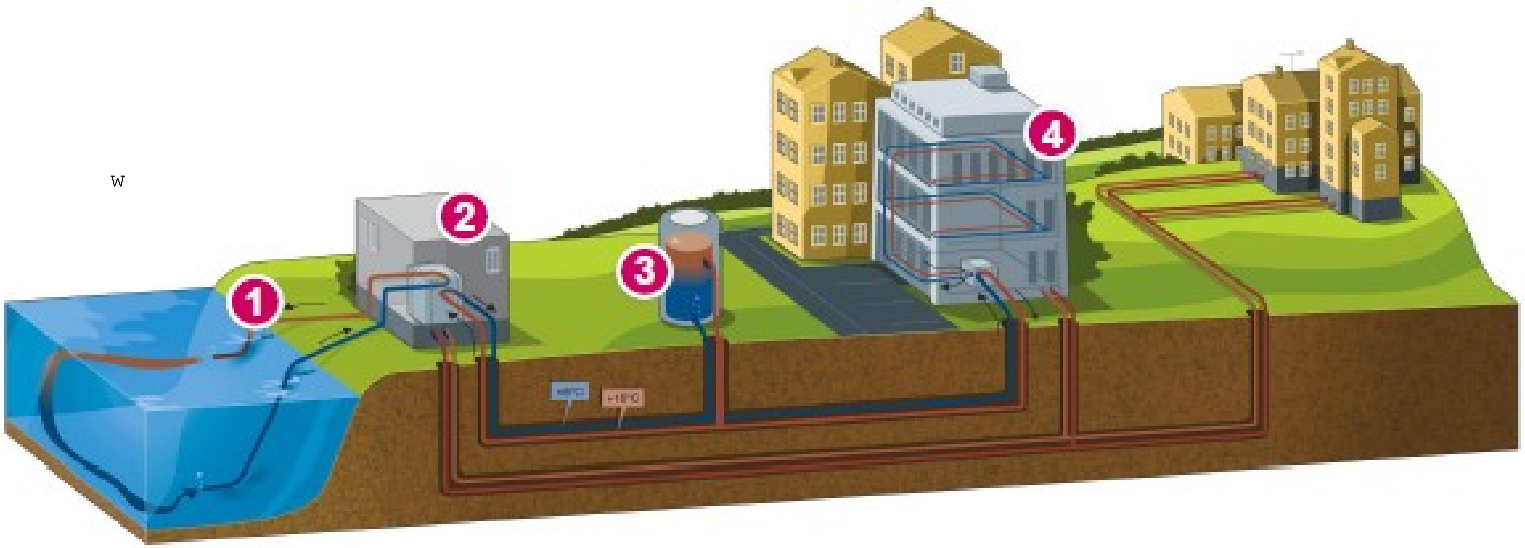
• Heat	3 287 GWh/year
• Power	930 GWh/year
• Cooling	313 GWh/year

Source: www.fortum.com

Sea water energy generation

This is how it works

W



1. Cold seawater used to cool the closed water loop of the District Cooling system. The seawater is then returned to the lake

2. Energy from the district cooling system is recovered and recycled in the district heating system

3. Nighttime and times when the need for cooling is limited, cold water is stored in the accumulator

4. The low temperature in the district cooling system is transferred to the building's closed loop distribution system via a heat exchanger.

Fortum

Source: www.fortum.com

Sea water energy generation

Heat Pump in focus

- Fortum has 6 bigger heat pump plants in Stockholm, most of them are designed to produce heat and cooling simultaneously.

Site visit

	Heating	Cooling
– Ropsten1 & 2	150 MW	0 MW
– Ropsten 3	100 MW	110 MW
– Nimrod	36 MW	48 MW
– Hammarby	230 MW	40 MW
– Kista/Akalla	25 MW	48 MW
– Vilunda	44 MW	10 MW

Source: www.fortum.com

Outlook

- increase of energy efficiency e.g. high- efficient heating, cooling and air-conditioning systems
- increasing use of renewable energy e.g. PV-Systems / Solar-heating/cooling and geothermal energy
- better building design, engineering and combination of technical systems, building construction and the renewable energies
- further development of regulations, education and training quality level especially for renewable energies
- best practice examples to promote solutions for future standards with a low energy demand supported e.g. by geothermal energy

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thank you for your attention!

Federal Ministry of Transport, Building and Urban Development

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