DEVELOPMENT OF GEOTHERMAL ENERGY IN EUROPE UNTIL 2008 AND SHORT-TERM PROSPECTS

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OUTLINE

- Introduction. Definitions. Technology outlook.
- Geothermal Resources in Europe
- European energy context
- Geothermal power production status
- Geothermal direct use status
- Where to go next? The future of geothermal development in Europe.

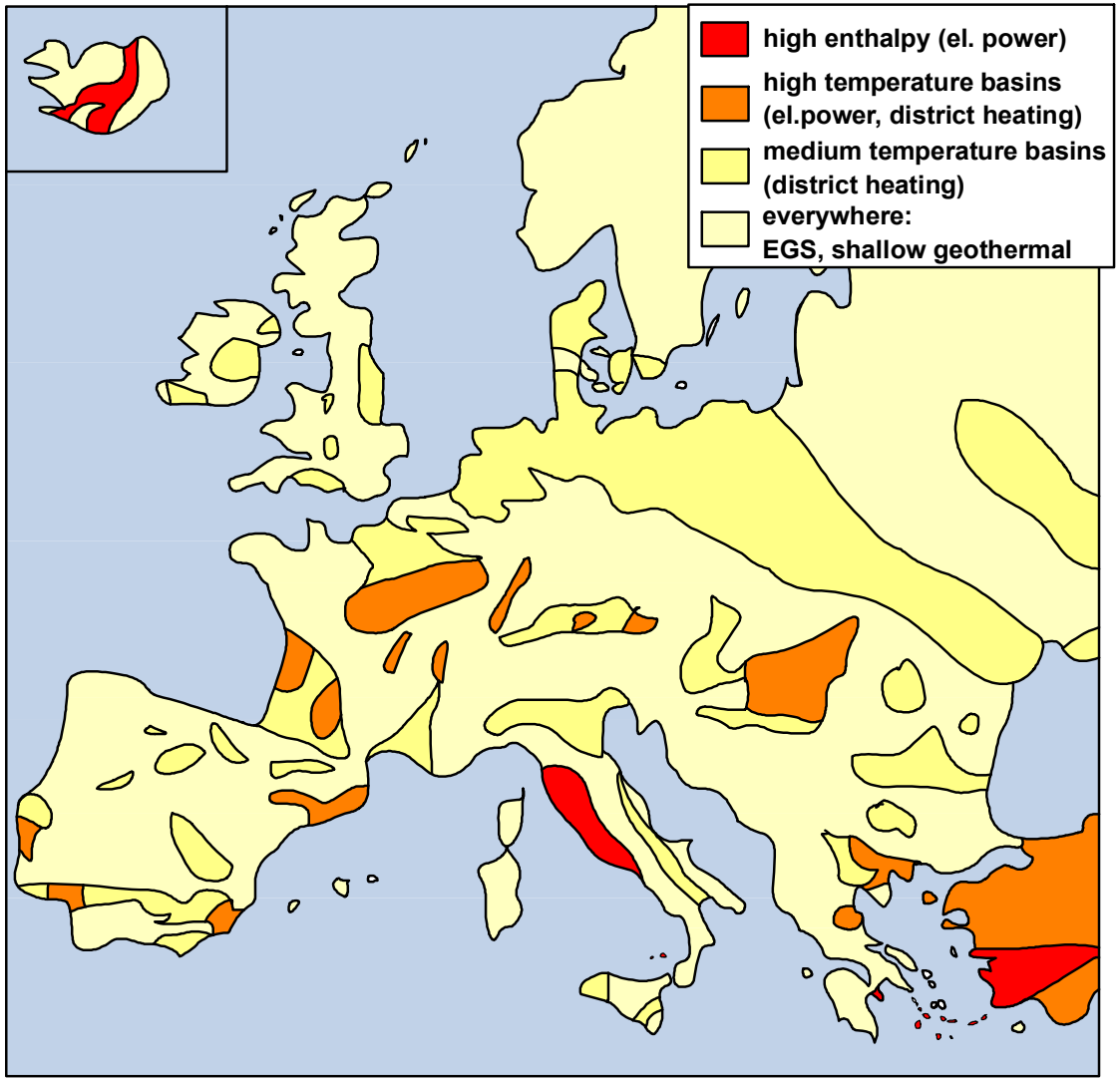
EGEC

- THE VOICE OF GEOTHERMAL ENERGY IN EUROPE

INTRODUCTION

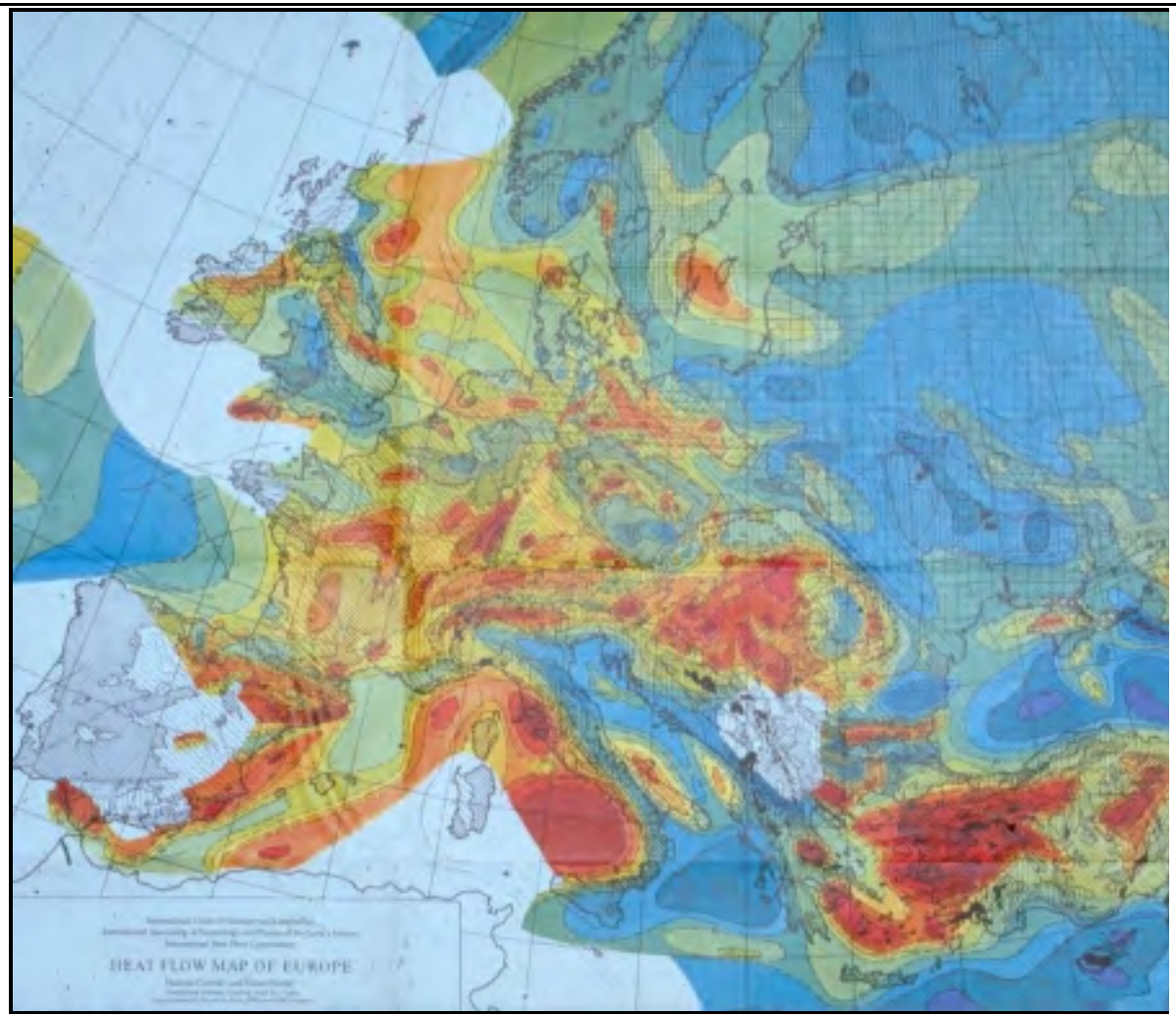
- *Geothermal Energy* is energy stored in the form of heat beneath the surface of the solid earth. This definition became official in Germany (VDI 4640) and it has been adopted by the European Geothermal Energy Council (EGEC).
- Geothermal energy can be reclaimed in two different ways:
  - in the form of electricity
  - the form of heat
    - each type of utilisation is distinguished by different technologies and applications.

RESOURCE ENVIRONMENTS



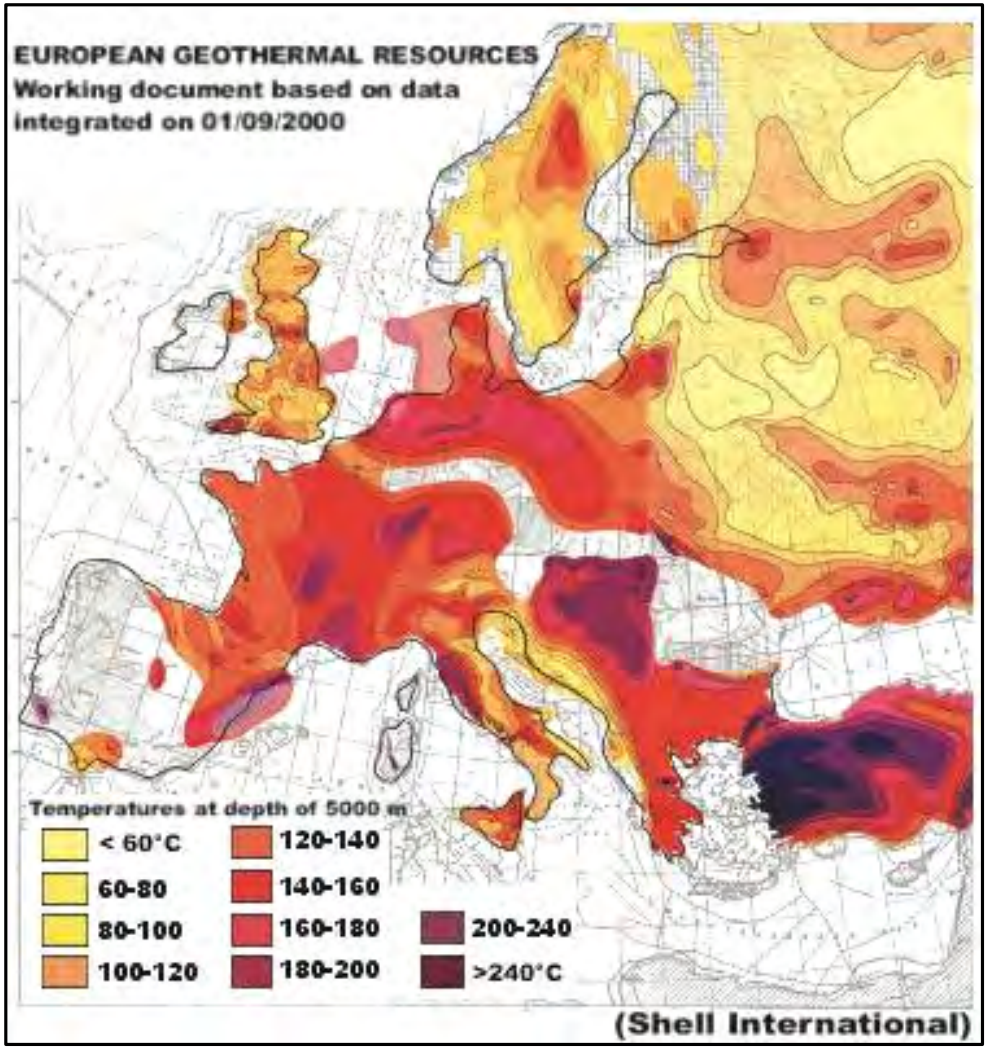
European geothermal resource environments

HEAT FLOW DENSITY MAP

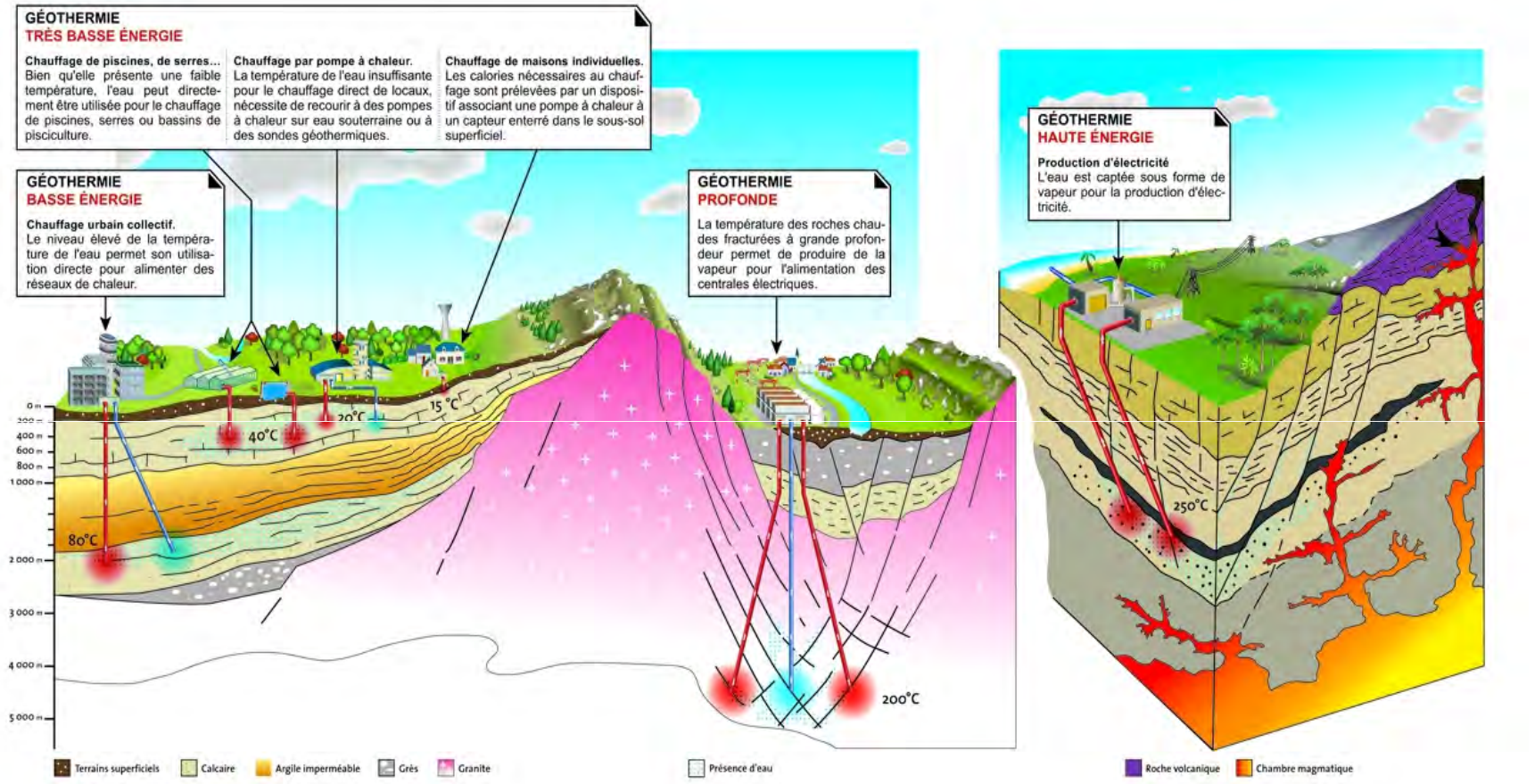


from Cermak and Rybach (1979)

TEMPERATURE DISTRIBUTION @ 5000 m depth



GEOTHERMAL ENERGY



www.geothermie-perspectives.fr

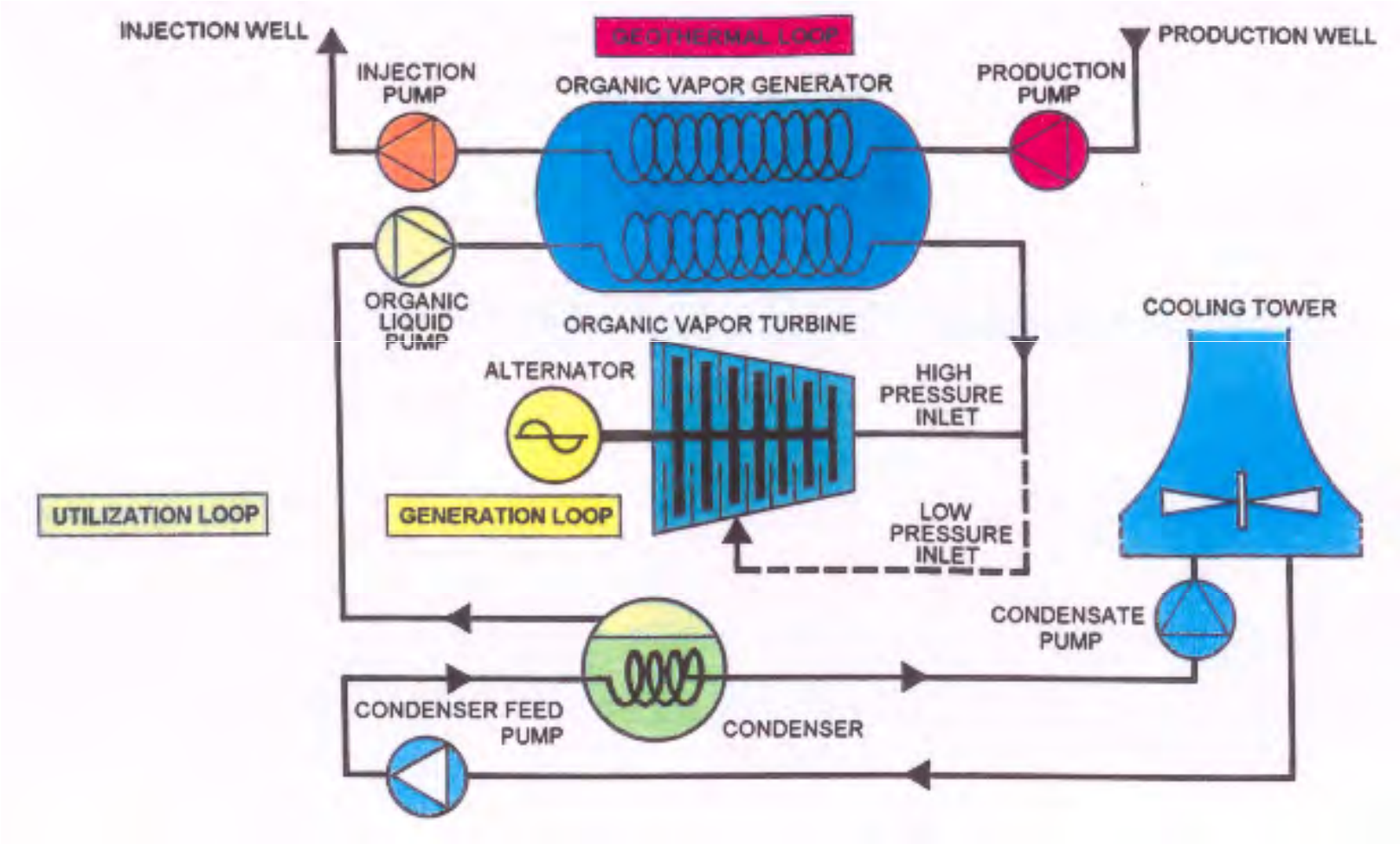
GEOTHERMAL ENERGY USES

- **Shallow Geothermal Energy for heating and cooling,**
  0-400 m deep, ground source heat pumps

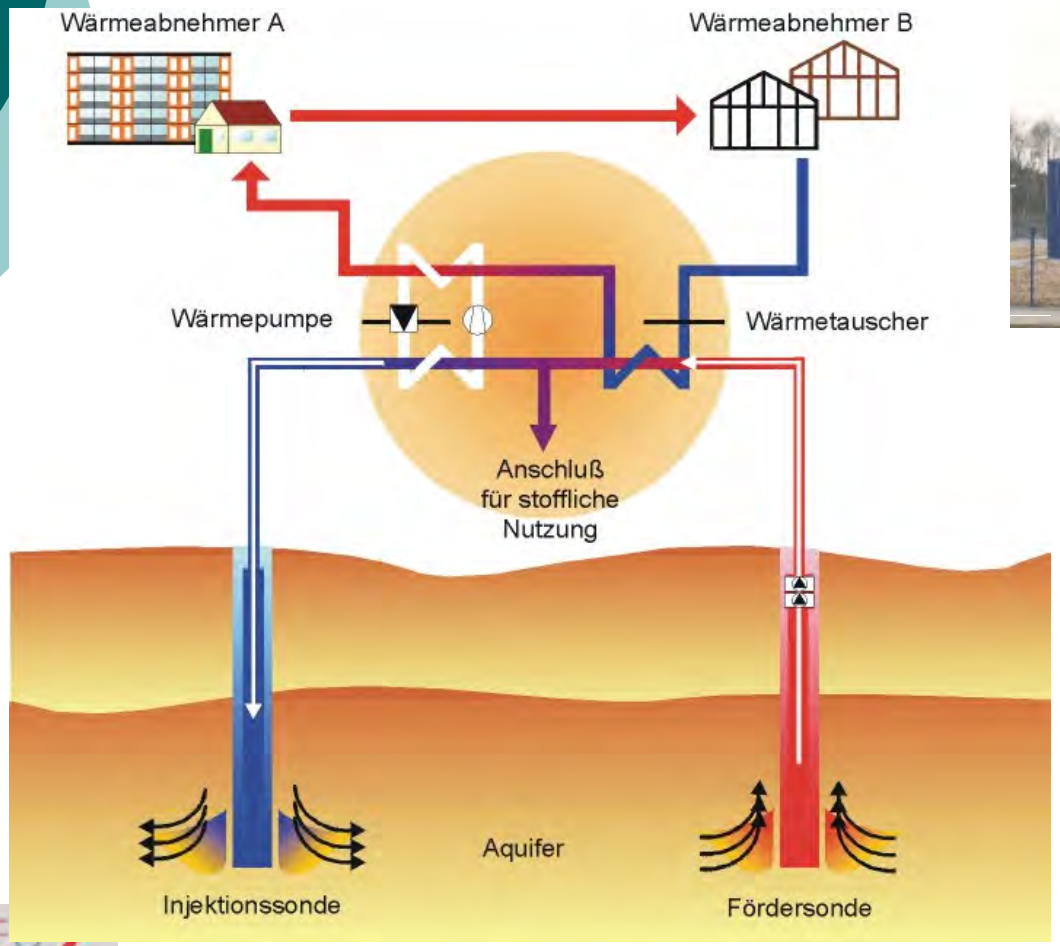
- **Deep Geothermal Energy for "direct use", heating, cooling, process heat**
  400-3000 m deep

- **Geothermal Power Production**
  up to 5000 m deep

POWER GENERATION ORGANIC RANKINE CYCLE



DEEP GEOTHERMAL ENERGY



Graph: GTN

Geothermal heating plant Neustadt-Glewe photo O. Joswig

doublet system, used since the late 1970s in France and since 1984 in (Eastern) Germany

GEOTHERMAL POWER

Low-temperature geothermal power

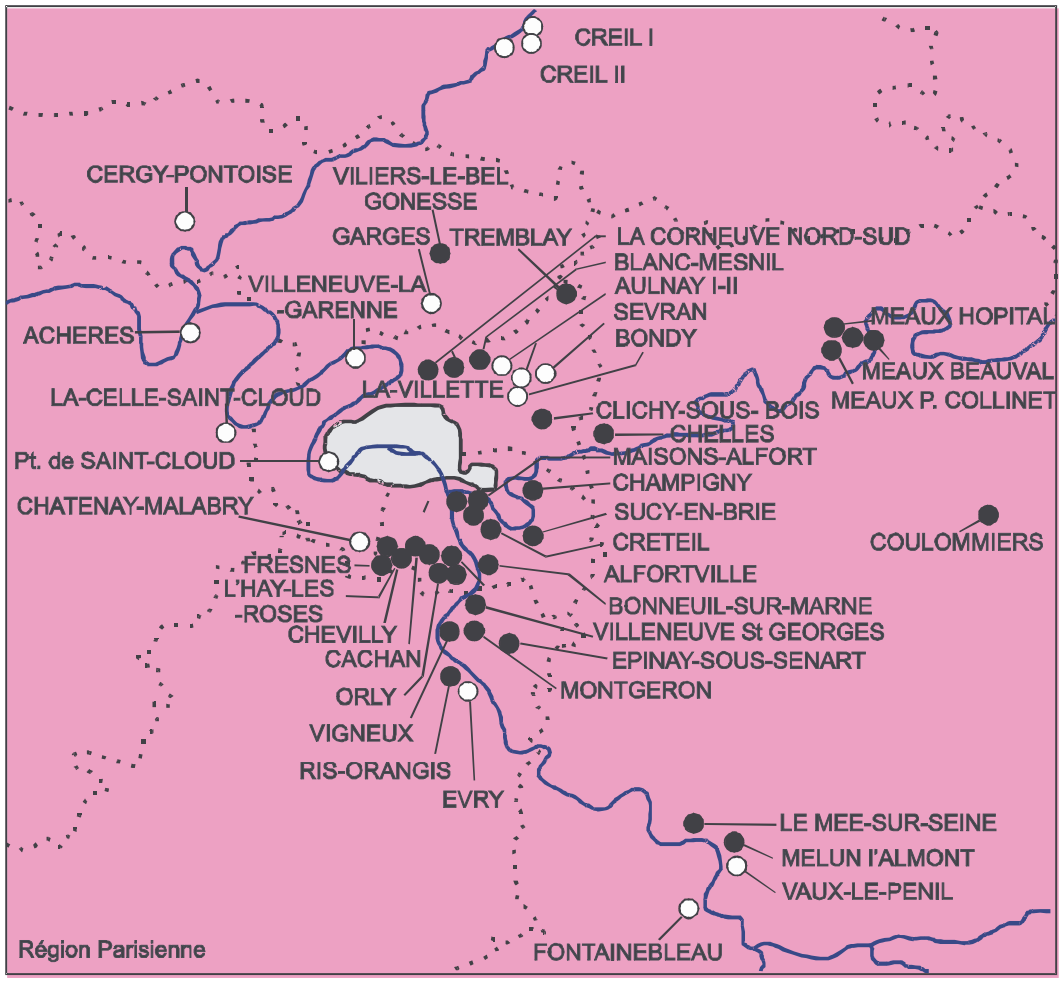
Example:
Bad Blumau (Austria)

ORC-turbine
- **250 kW el. output**
- **air-cooled**

operational since end 2000

(Photos: Prmat/Rogner)

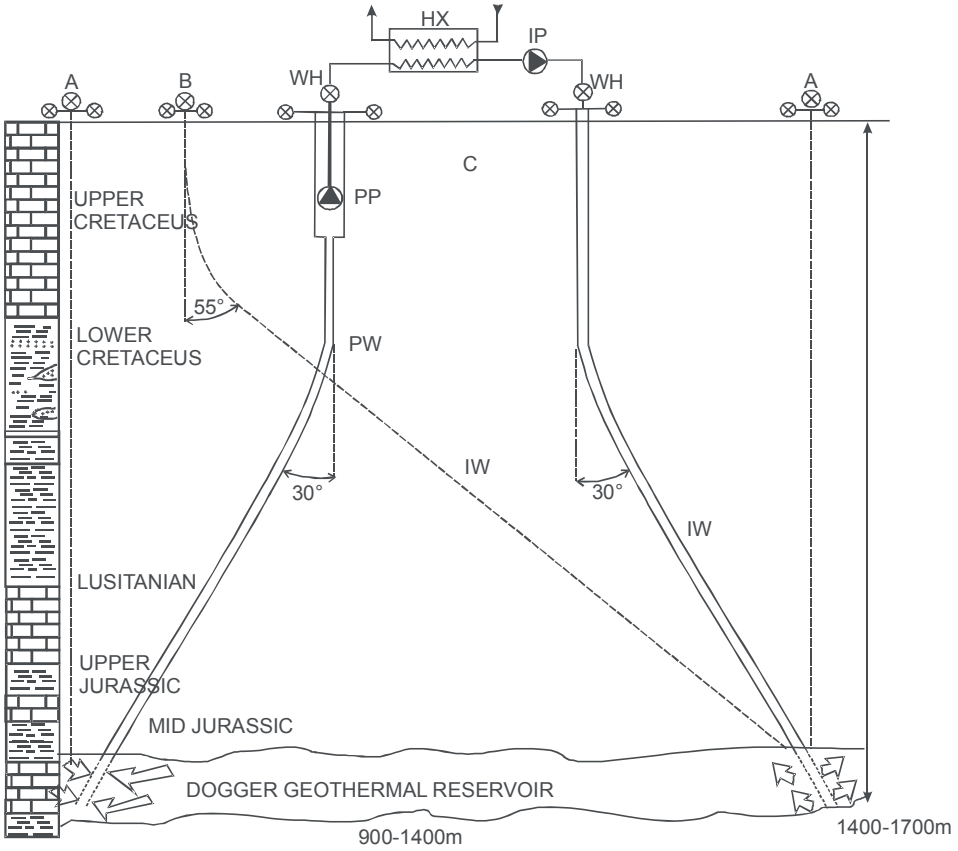
GEOTHERMAL DISTRICT HEATING PARIS BASIN



Source: GPC, 2008

TECHNOLOGY OUTLOOK

THE GEOTHERMAL WELL DOUBLET OF HEAT PRODUCTION



A - two vertical wells
B - 1 vertical, 1 deviated
C - two deviated wells

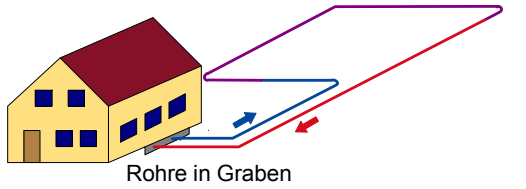
PP production pump
IP injection pump
HX heat exchanger
PW production well
IW injection well
WH wellhead

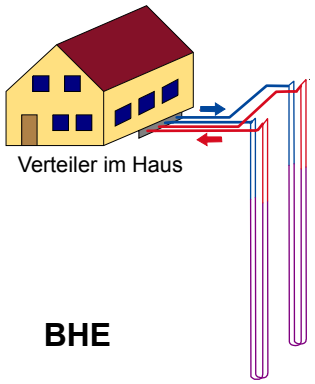
SHALLOW GEOTHERMAL ENERGY FOR HEAT AND COLD

The various shallow geothermal methods

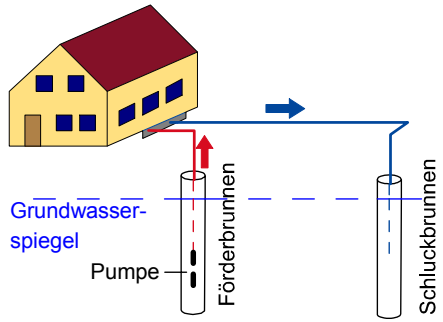
- **horizontal loops** — **1.2 - 2.0 m depth**
- **borehole heat exchangers (vertical loops)** — **10 - 250 m depth**
- **energy piles** — **8 - 45 m depth**
- **ground water wells** — **4 - 50 m depth**
- **water from mines and tunnels**

about 80 % of all systems





BHE

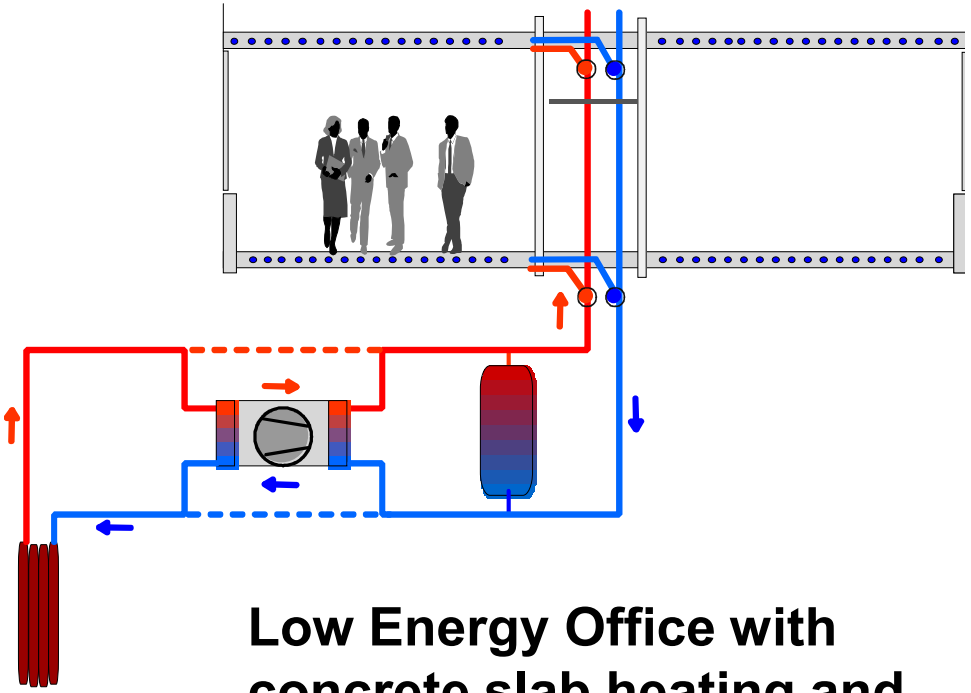


Groundwater wells

SHALLOW GEOTHERMAL ENERGY

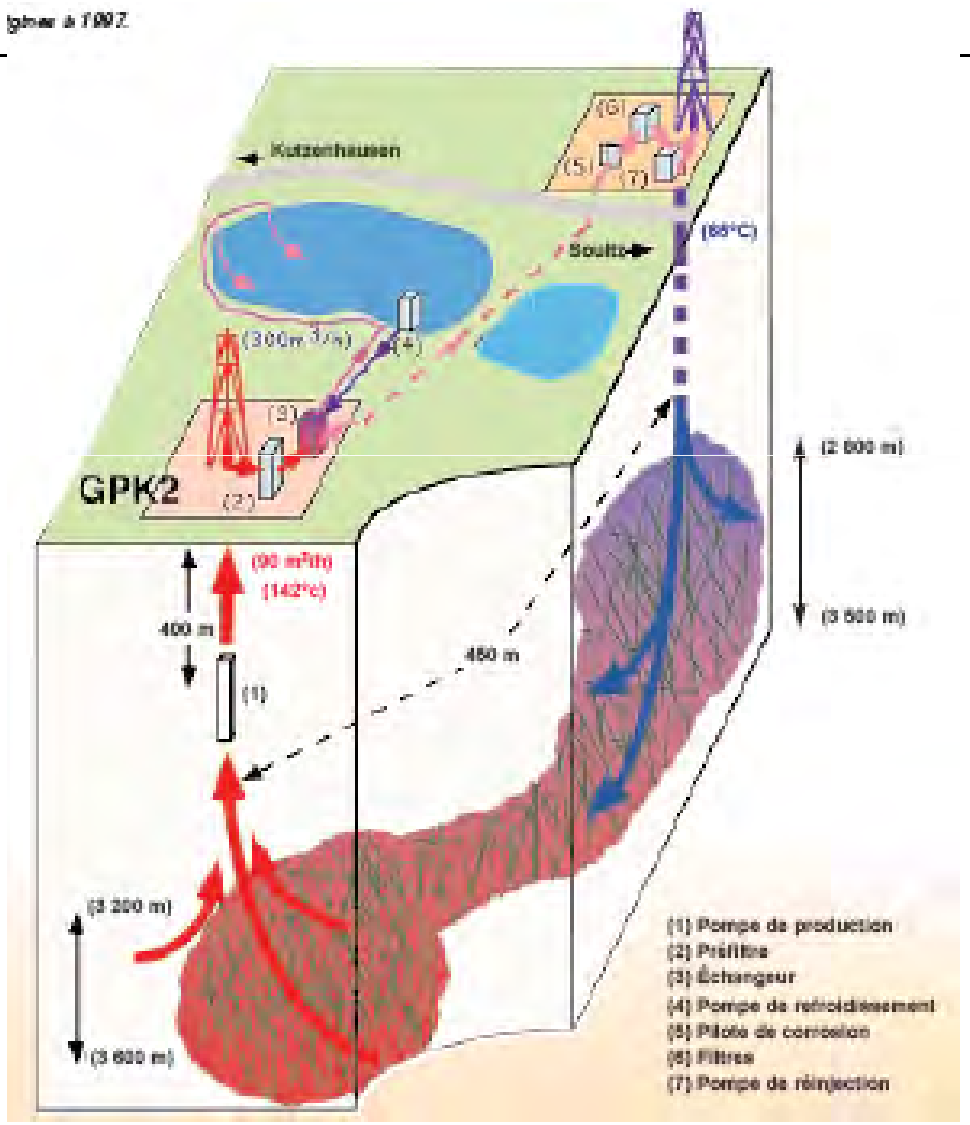
Photo: EWS

Example of office building:
Vika, Aachen



Low Energy Office with concrete slab heating and cooling,
28 BHE each 43 m deep

ENHANCED GEOTHERMAL SYSTEMS



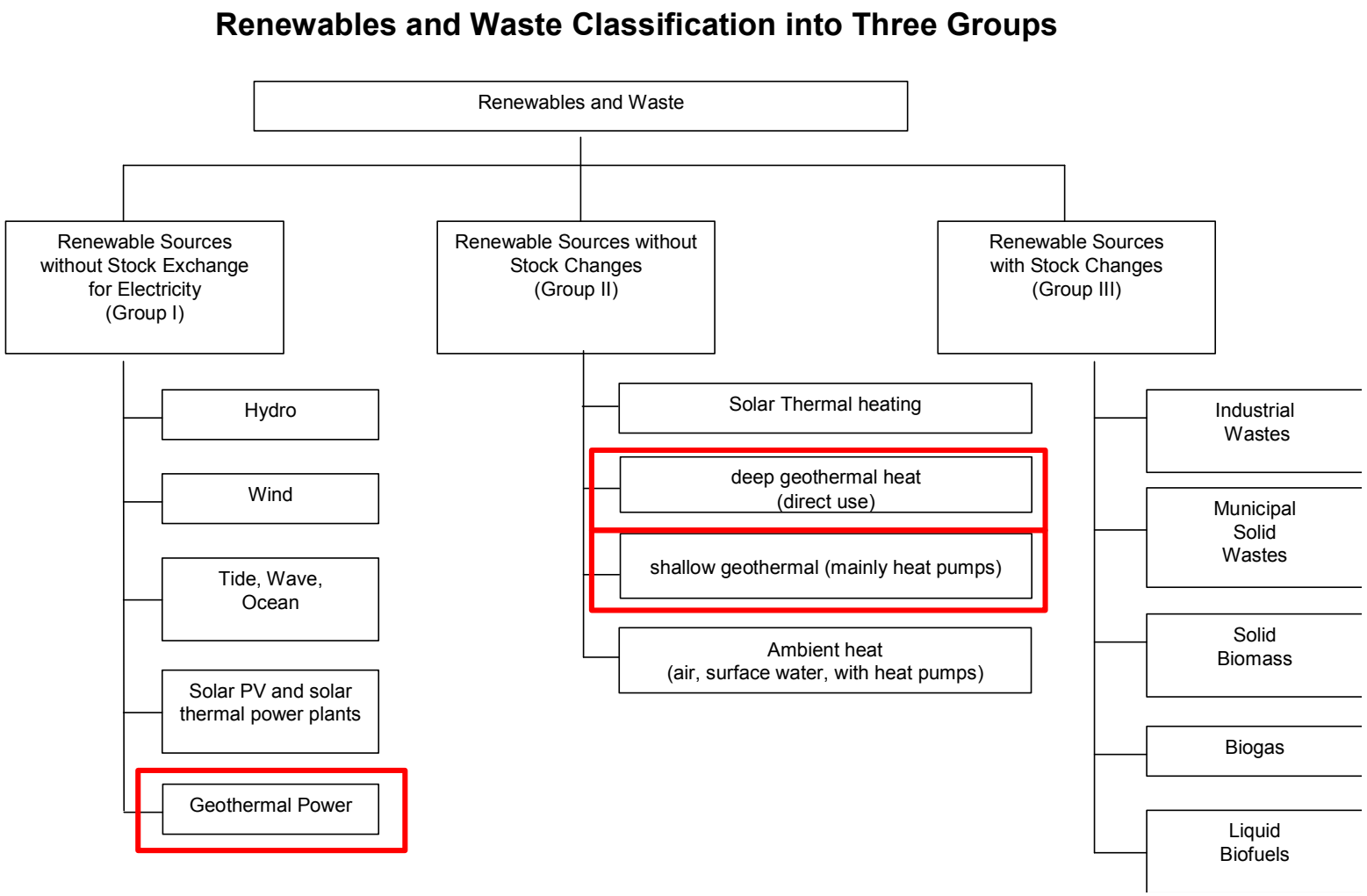
EUROPEAN ENERGY BACKGROUND

- The EU is the world's largest energy importer, relying on imports for 50% of its energy needs.
- With an energy demand forecast likely to grow by 1-2 % a year, that figure will, over the coming 20-30 years, rise to 70%.
- EU is committed by the Kyoto protocol, to reducing greenhouse gas emissions by 8% below the 1990 level in 2008 -2012.
- The EU energy strategy is being driven by three imperatives
  - to ensure security of supply,
  - to ensure competitive energy prices for European business and
  - to reduce the climate change impacts of its energy use.
- The key issue is to create a genuine single energy market, and to integrate many of its near neighbors into it (Europe's World, 2007).
- On January 10, 2007, the European Commission released an "energy package" including a renewable energy roadmap. Currently, the European Commission prepares a plan on how to divide this renewable energy share over individual member states.

DATA SOURCES

- WORLD GEOTHERMAL CONGRESS 2005
- European Heat Pump Ass. (EHPA) sales figures
- European Geothermal Energy Council (EGEC)
- Eurobserv'ER – Geothermal Barometer
- K4RES-H – Deliverable 2
- 2007 Country updates:
  - Albania, Germany, Greece, Ireland, Italy, Macedonia, Poland, Russia, Switzerland, Turkey

CLASSIFICATION OF RENEWABLE ENERGY SOURCES ALTERNATIVE SUGGESTION OF EGEC

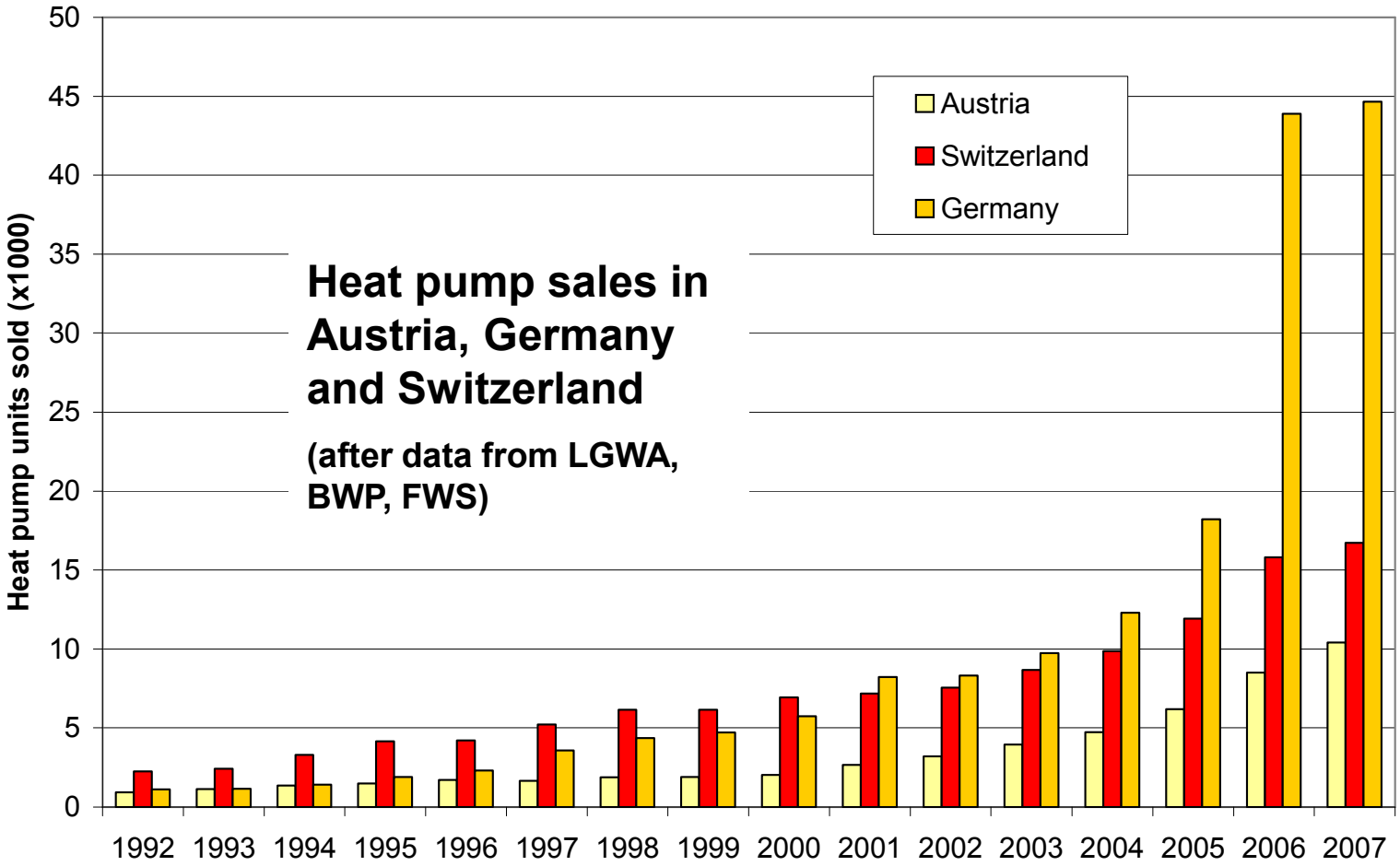


Ground Source Heat Pump market and deployment in Europe. Status 2008

- old and strong
- recent and strong
- emerging

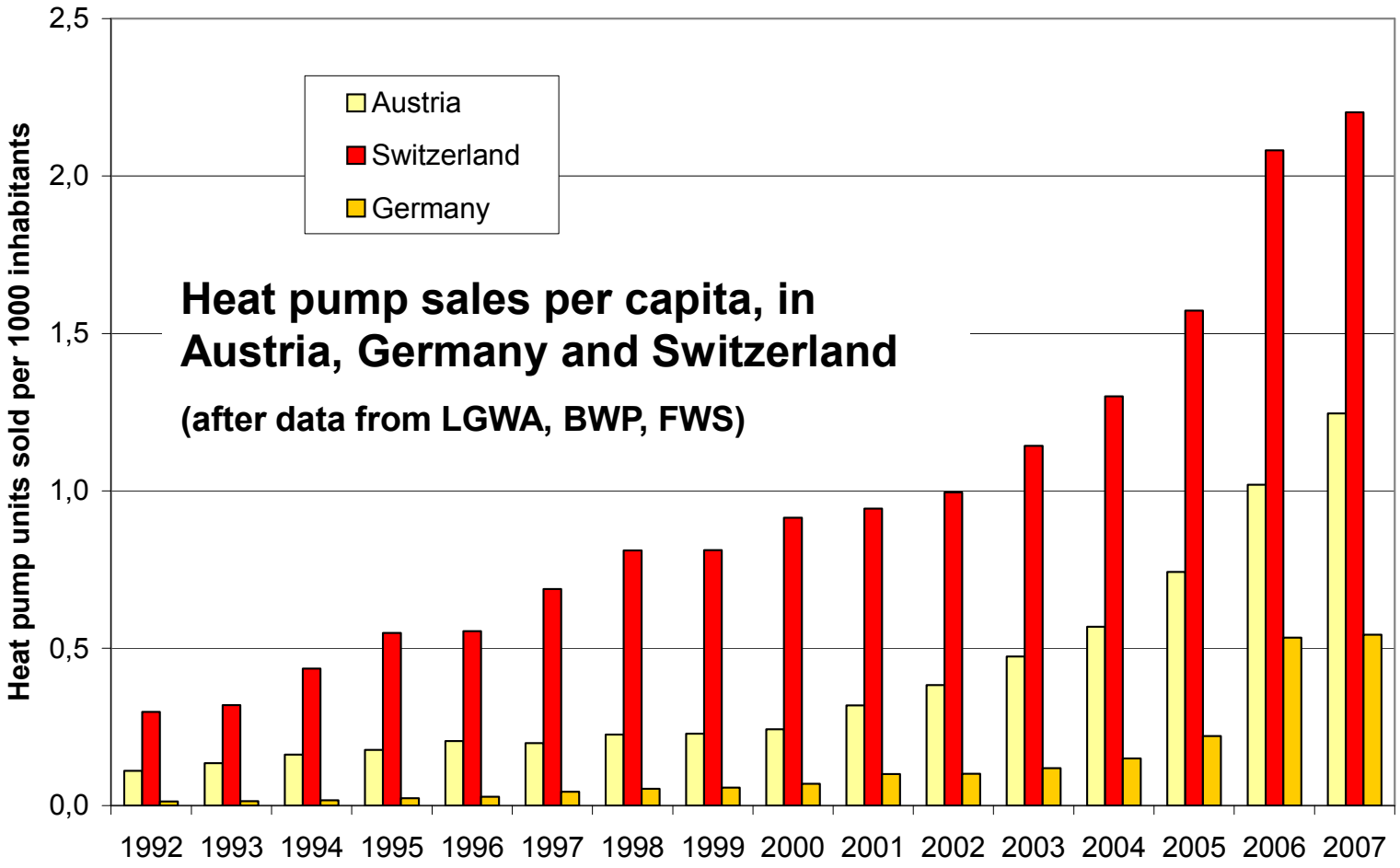
Status 2008

Market Data Europe



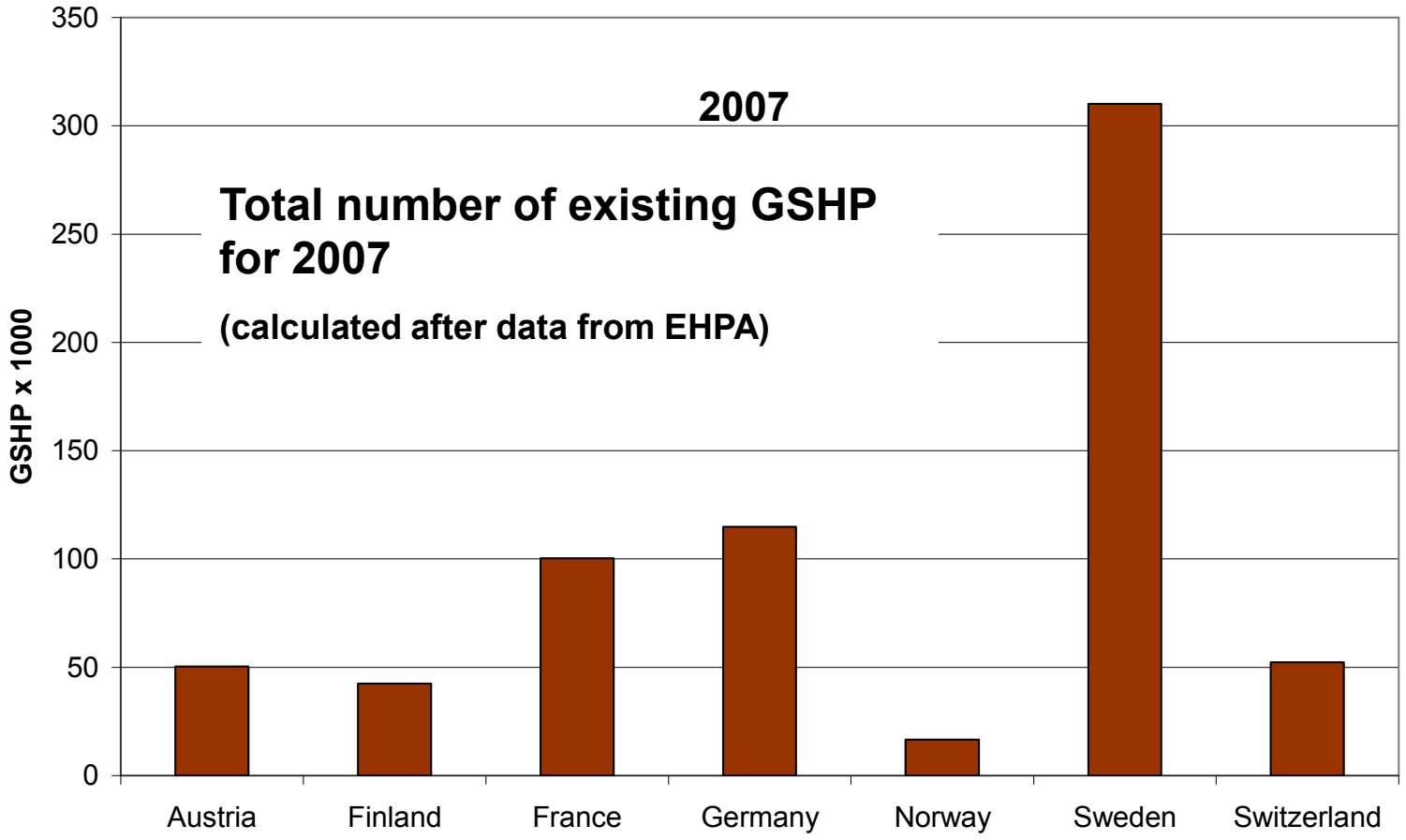
Status 2008

Market Data Europe



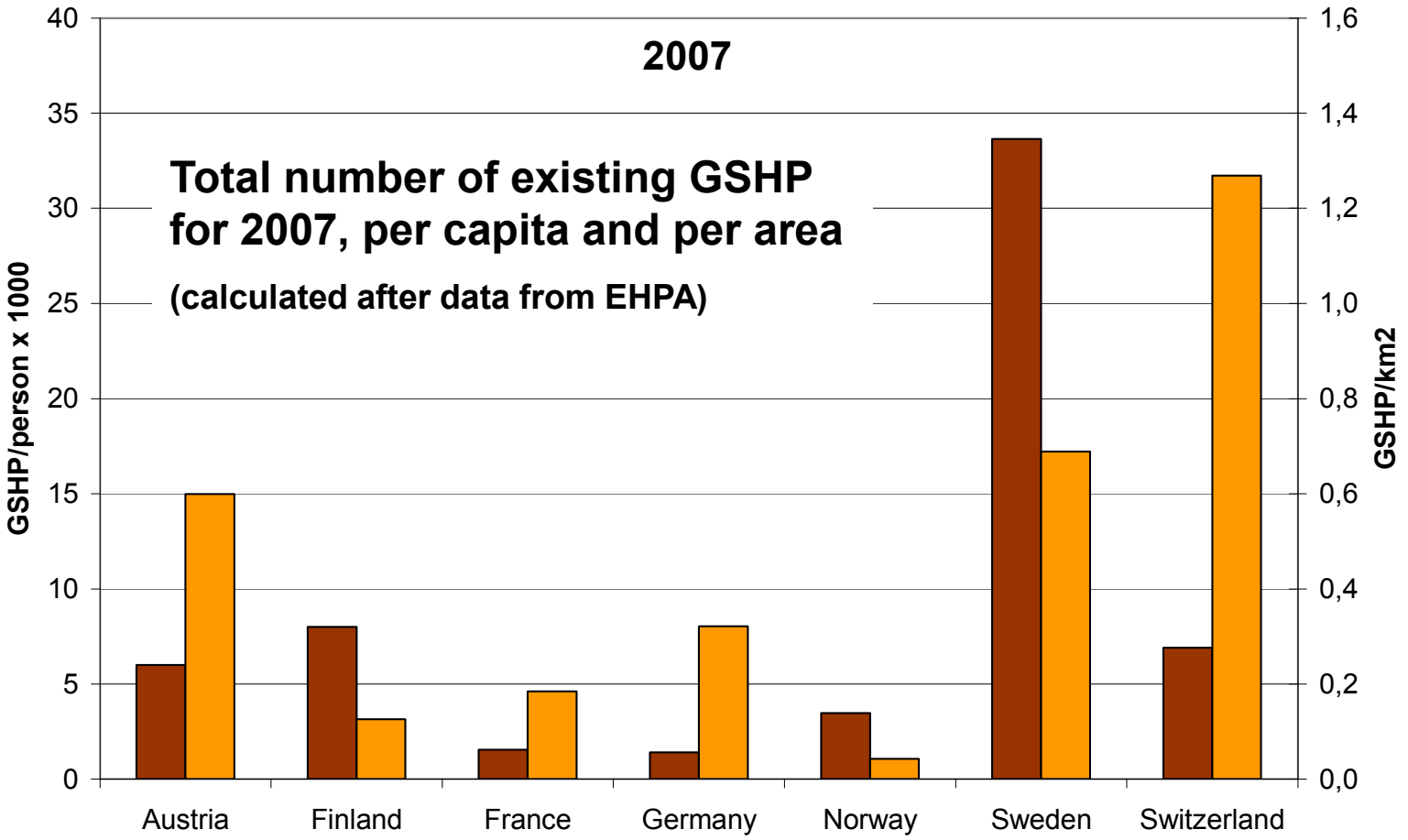
Status 2008

Market Data Europe



Status 2008

Market Data Europe



Problems related with the “boom” in GSHP:

- **Lack of drilling capacity**
- **Problems with quality of work**
- **Licensing procedures need be fast, but without loss in environmental protection!**

- **=> More “non-technical” action like communication, education, training, standards, etc. required**

Existing Geothermal District Heating systems in Europe

Brochure of EGEC, for download at www.egec.org

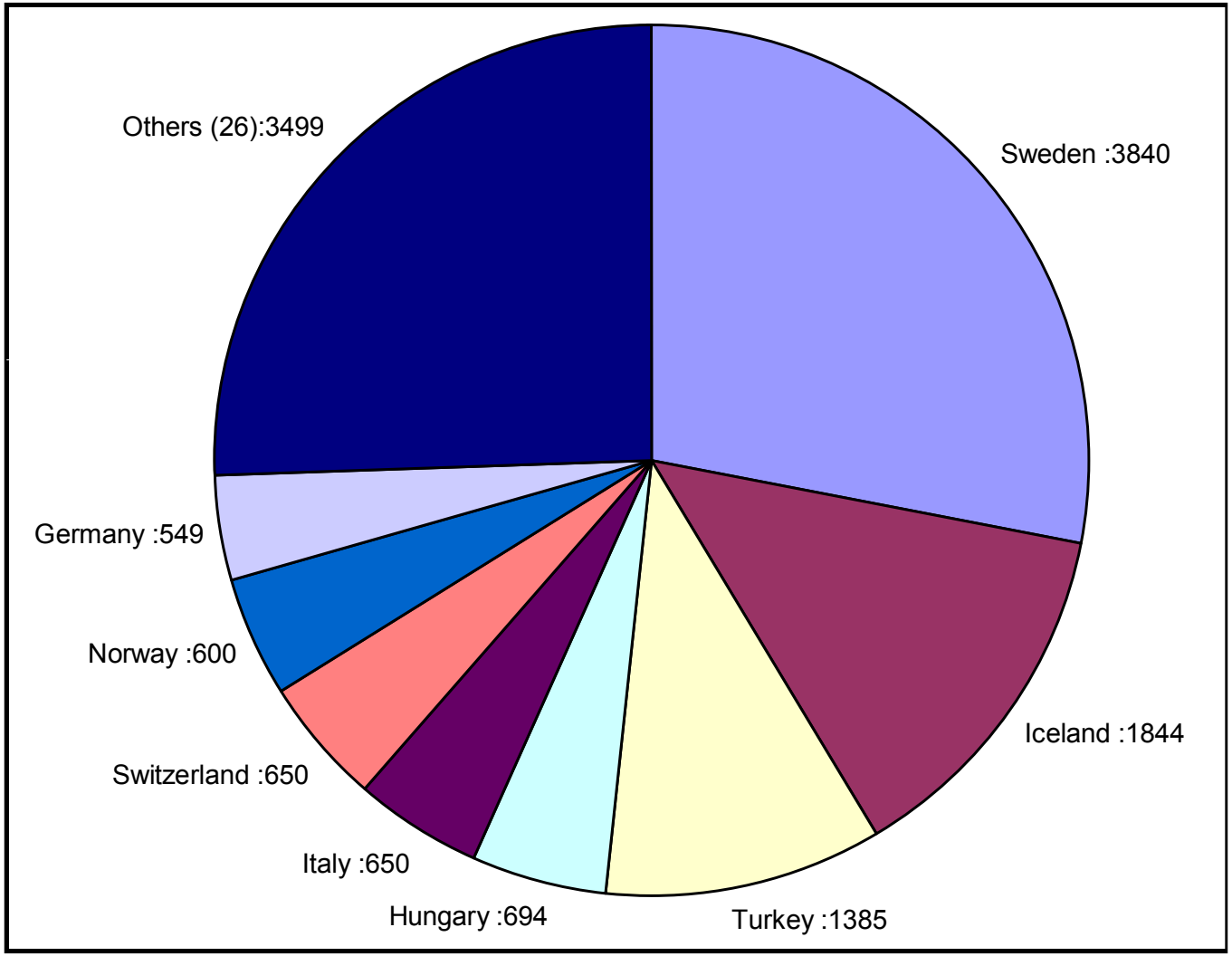
EGEC

Geothermal District Heating within the EU

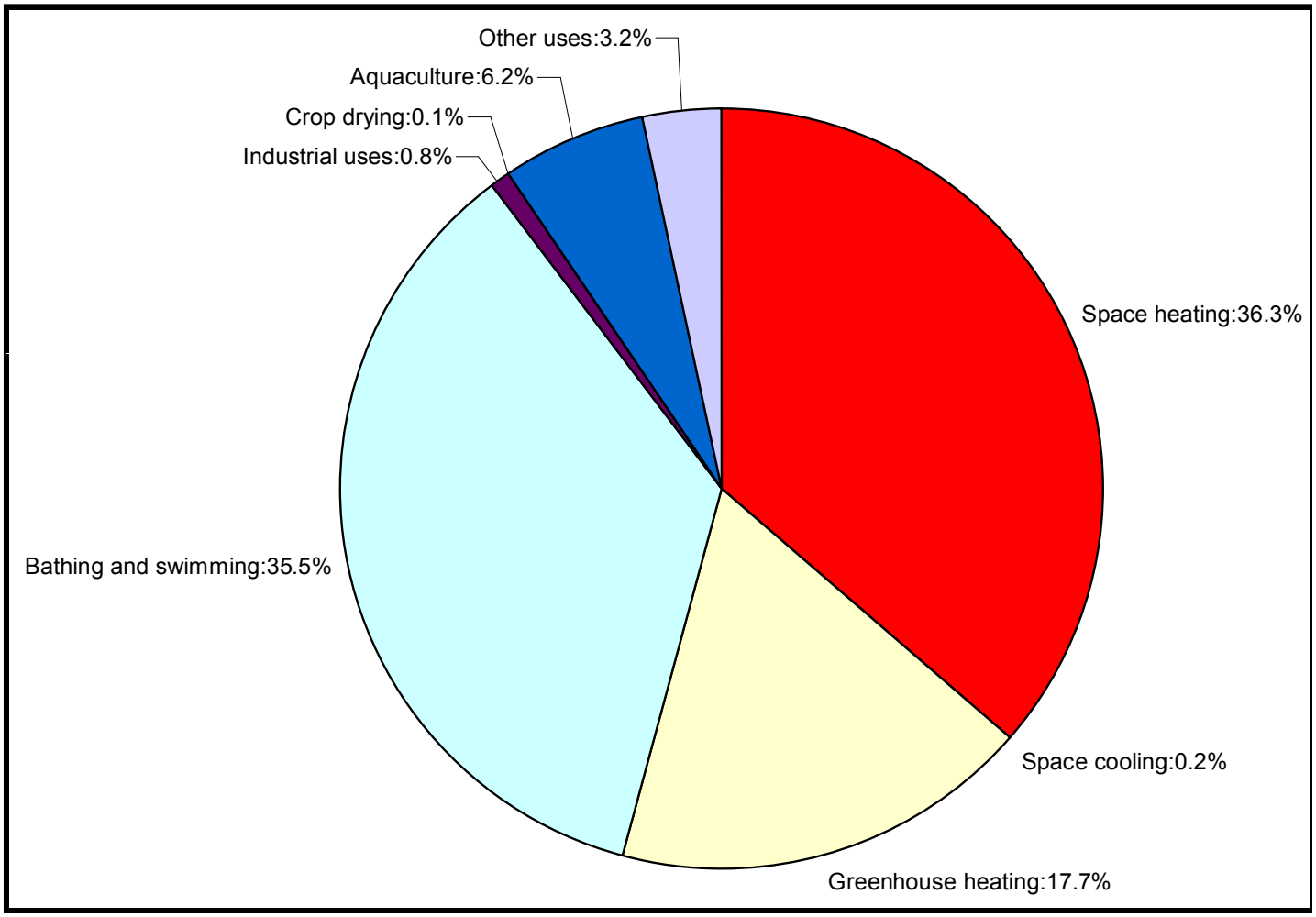
- France: 38 DH plants in Paris region (e.g. Cachan, Epinay sous Senart, Tremblay, Meaux, , Chevilly-La Rue), others in Aquitaine
- Italy: Po-plain (Ferrara), Tuscany
- Germany: Northern Germany (e.g. Waren, Neustadt-Glewe), Munich area (e.g. Erding, Unterschleissheim, Pullach)
- Poland: Northern Poland (e.g. Pyrcyze), Tatra foothills (Zakopane)
- Austria: North and South of the Alps (e.g. Altheim, Bad Blumau)
- Hungary: all the Pannonian basin (e.g. Hódmezövásárhely, Kistelek)
- others: Denmark (Thisted, Copenhagen), Sweden (Lund, Malmö), Lithuania (Klaipeda), and more...

EUROPE GEOTHERMAL DIRECT USE STATUS

INSTALLED CAPACITIES (MWt) COUNTRY WISE



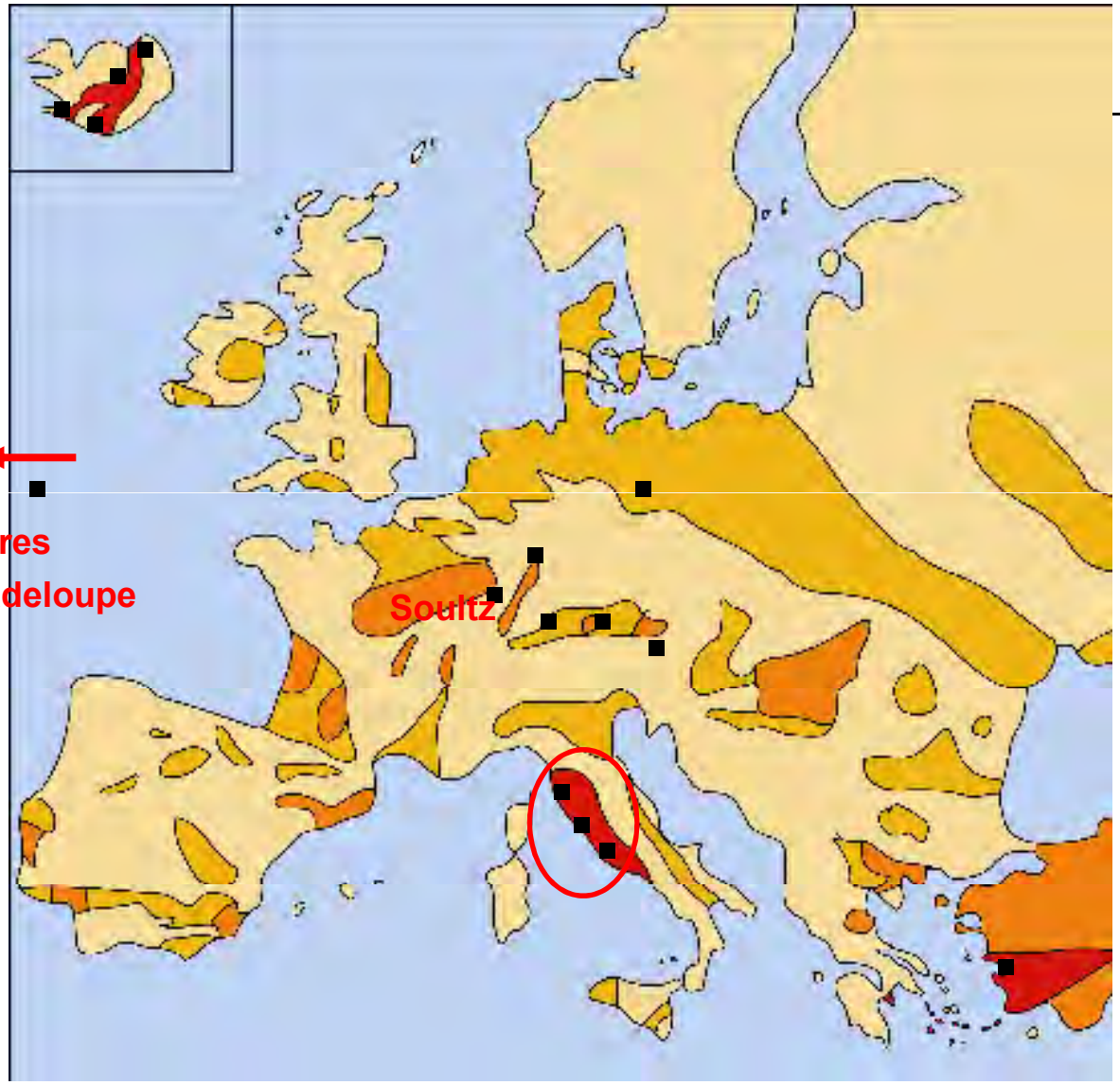
EUROPE GEOTHERMAL DIRECT USE BREAKDOWN



Deep Geothermal Energy

- In most countries, geothermal district heating needs some investment support, reduced interest loans, etc. to become economic.
- Cascade uses (district heating, industry, agricul-ture, and other) improves economy, but usually are very difficult to achieve due to business obstacles, distances, etc. (successful example: Nangong geothermal village, China)
- The main financial obstacle is the heat distribution network (example: Bruchsal, D)
- For heat distribution, Eastern European countries may have an advantage due to existing networks

Geothermal Electric Power



Geothermal Power Plants:

- -Italy= 811 MWe
- -Iceland= 421 MWe
- -Turkey= 38 MWe
- -Portugal= 23 MWe
- -France= 15 MWe
- -Germany= 3 MWe
- -Austria= 1 MWe

THE FUTURE OF GEOTHERMAL DEVELOPMENT
EREC'S RENEWABLE ENERGY ROADMAP

Table 5: Renewable Electricity Installed Capacity Projections

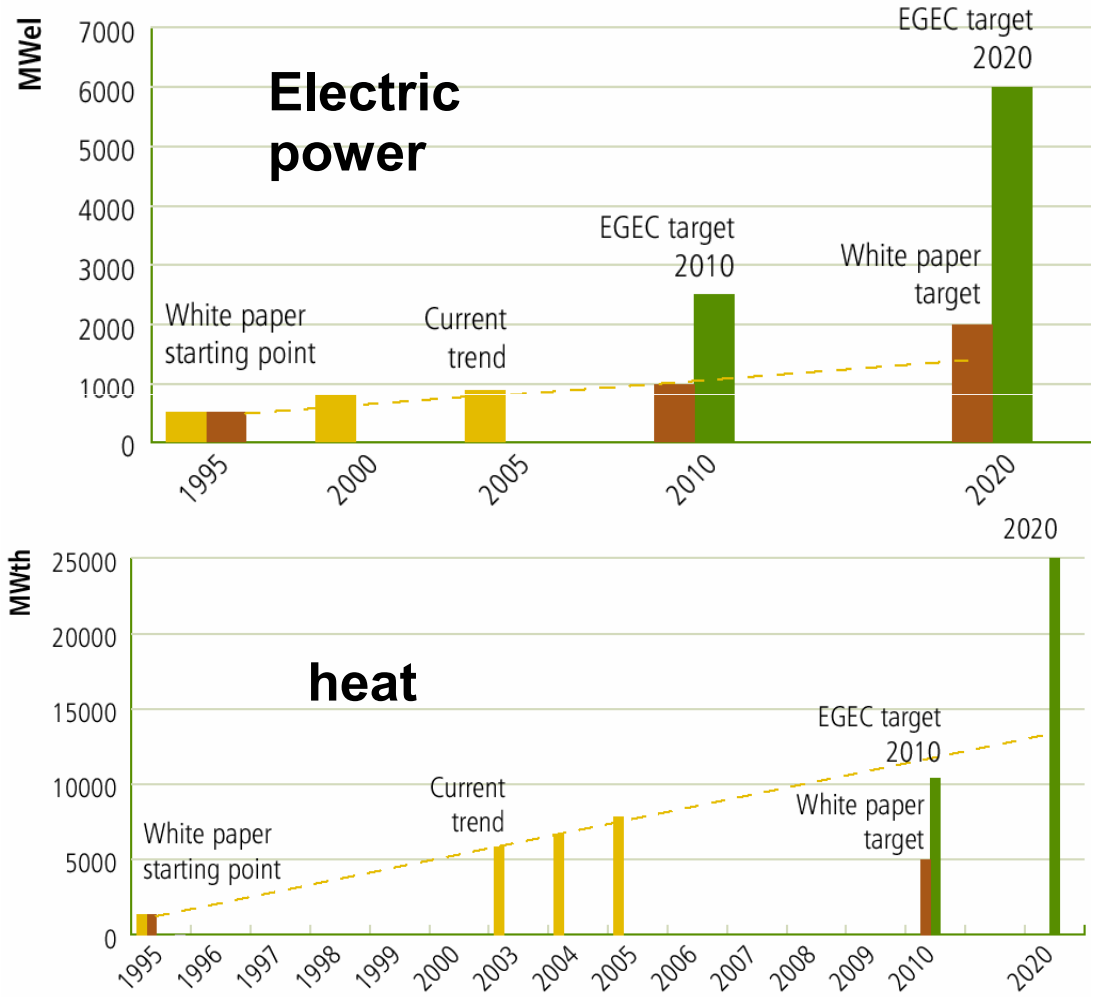
TYPE OF ENERGY	2000 EUROSTAT	2004 EUROSTAT	Annual growth rate 2000-2004	PROJECTION 2010	Annual growth rate 2004-2010	PROJECTION	Annual growth rate 2010-2020
1. Wind	13.2 GW	33.6 GW	26.3	80 GW	15.6	180 GW	8.5
2.Hydro	93 GW	107.5 GW	3.7	113 GW	0.8	120 GW	0.6
3. PV	0.18 GW_P	0.86 GW_P	47.8	8 GW_P[3]	45.0	52 GW_P[3]	20.6
4.Biomass	9.5 GW_e	13.1 GW_e	8.6	25 GW_e	11.2	50 GW_e	7.2
5.Geothermal	0.6 GW	0.66 GW	2.4	1 GW	7.2	2 GW	7.2

Table 7: Renewable Heat Generation Projections

TYPE OF ENERGY	2000 Eurostat	2004 Eurostat	AGR 2000-2004	Projection 2010	AGR2004-2010	projection 2020	AGR 2010-2020
Biomass for heat	44.7 Mtoe	48.4 Mtoe	2.0%	65 Mtoe	5.0%	105 Mtoe	4.9%
Solar thermal	0.38 Mtoe	0.68 Mtoe	15.6%	2 Mtoe	19.7%	12 Mtoe	19.6%
Geothermal	0.66 Mtoe	1.5 Mtoe	22.8%	4 Mtoe	17.7%	8 Mtoe	7.2%

Source: Antics & Sanner (EGEC/EREC 2007)

FUTURE DEVELOPMENT TRENDS
EGEC FORECASTED TARGETS

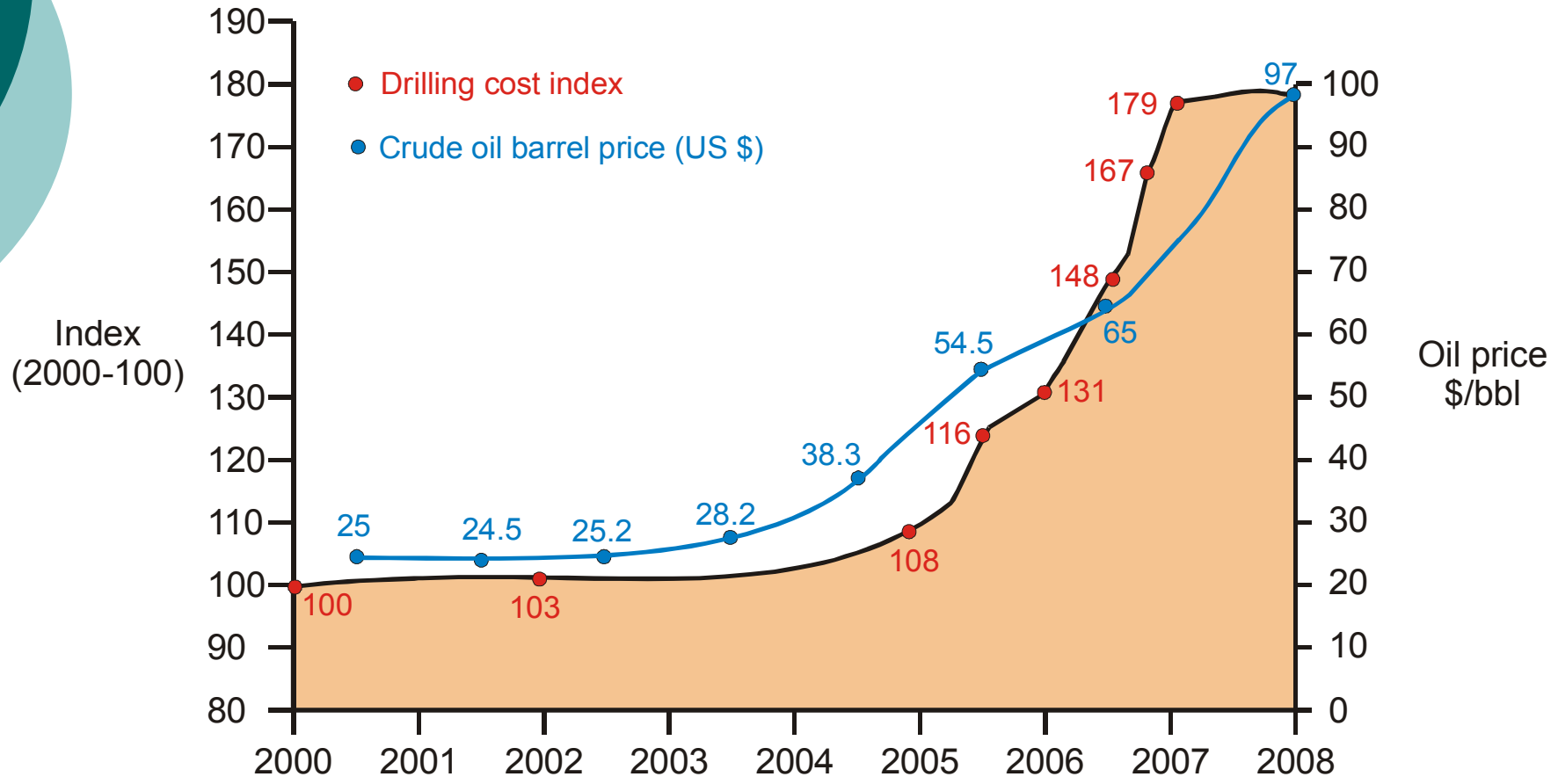


Source: Antics & Sanner (EGEC/EREC 2007)

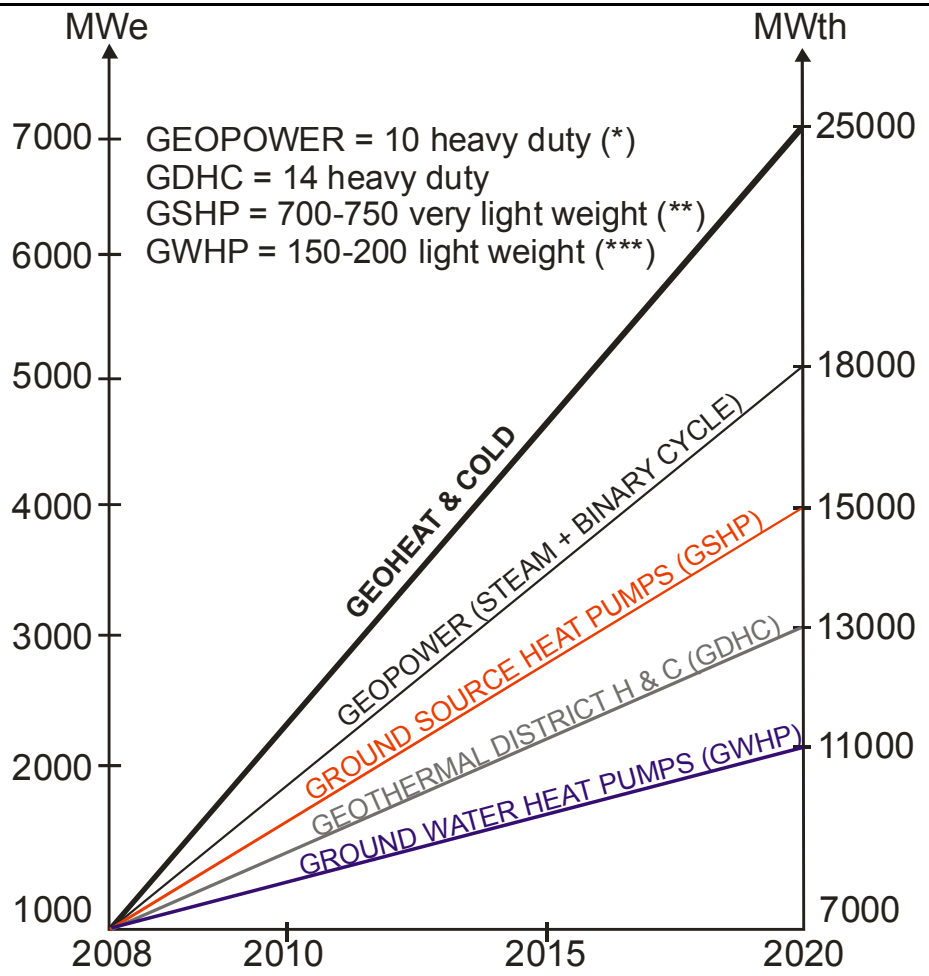
GEOTHERMAL (NEW) POWER PLANT TIME TABLE

PHASE \ YEAR	1	2	3	4	5	6	7	8	9
EXPLORATION	■	■							
PRE-FEASIBILITY			■						
FEASIBILITY				■	■				
PLANT COMMISSIONING						■			
PLANT DESIGN						■			
PLANT CONSTRUCTION							■	■	
START UP/OPERATION									->

DRILLING COSTS VS CRUDE OIL PRICES



DRILLING RIG FORCE REQUIREMENTS



(*) 200-350 t hook load diesel electric
(**) percussion air/foam drilling
(***) rotary mud drilling

INVESTMENT NEEDS (€/kW and bn €)

UNIT INVESTMENT COSTS (€/kW)

- Geopower
  - Steam cycle 2000
  - Binary cycle (*) 2500
- Geoheat and cold
  - District heating 2000
  - GSHP 2000
  - GWHP 750

TOTAL GROSS ESTIMATES (2008-2020) **bn €**	
Geopower	6.4
Geoheat and cold	31
Grand total	**37.4**

(*) associated with heat (CHP)

FUTURE DEVELOPMENT TRENDS

Geothermal power

- Currently 1060 MW installed capacity, surpassing fast the target of 1000 MW set forth for 2010 by the White Paper from 1997
- The target value of 6000 MW for 2020 from the Brussels Declaration (EGEC, 2009)

FUTURE DEVELOPMENT TRENDS

Main developments expected in the geothermal power sector

- Improved energy conversion efficiency for geothermal power plants, adapted to the reservoir temperatures on site, for conventional turbines as well as for ORC, Kalina, etc.
- Successful demonstration of EGS (Enhanced Geothermal Systems) on key sites like Soultz-sous-Forêts, France, and dissemination of the technology to other sites and regions
- Increased overall efficiency in geothermal CHP
- Improvement of exploration methods, installation technologies, and system components (pumps, pipes, turbines, etc.)

FUTURE DEVELOPMENT TRENDS

Geothermal heating and cooling

- Geothermal heating from medium to low temperature source installed capacity exceeds 2500 MWt and has a increasing trend of about 50 MWt per year. This growth rate could lead to a doubling of the forecast capacity of 6000 MWt by 2020 set forth by the Brussels Declaration
- Shallow geothermal energy, ground source heat pumps (GSHP), installation growth rate is even more spectacular, and a capacity of 8000 MWt could be reached if 10% growth per year is maintained (Rybach, 2006), reaching 33000 MWt
- For the heating sector, the deep and shallow energy production combined is bound for reaching the ambitious target of 39000 MWt set forth in the Brussels Declaration.

FUTURE DEVELOPMENT TRENDS

Main developments expected in the geothermal heating and cooling sector

- Improved site assessment (incl. GIS-systems), exploration and installation, also for shallow systems, and dissemination of successful approaches from some countries to the whole EU
- Further increase of efficiency of ground source heat pumps, optimised system concepts, application of advanced control systems, improved components and materials (compressors, refrigerants, pipes, etc.)
- Construction of new district heating networks, and optimisation of existing networks and plants, in particular in East/South Eastern Europe and Turkey
- Increased application and innovative concepts for geothermal energy in agriculture, aquaculture, industrial drying processes, etc.
- Demonstration of new applications like de-icing and snow melting on roads, airport runways, etc., sea-water desalination, and geothermal absorption cooling.

FUTURE DEVELOPMENT TRENDS

Non-technical barriers and development needs

- Also non-technical development is of paramount importance, comprising administrative and legal clarity, suitable infrastructure in form of machines and skilled labour, information to the public, etc.
- For the legal and regulatory background, a process has been started in 2005 out of the geothermal and geological community; this action is know as the "Kistelek Process", after the small South-Hungarian town where the first meeting took place (see the "Kistelek Declaration", for download at www.egec.org).
- The activity was concluded through a EU-supported project called GTR-H.
- For the shallow geothermal sector, standardisation and quality certificates are introduced

EGEC Brussels declaration 11 February 2009

- ***> A major advantage of geothermal energy is the availability of the resource all day and night, throughout the year: a load to the grid, operating up to 100% of time (the best ratio of all energy technology !).***

EGEC Brussels declaration 11 February 2009

- ***> Geothermal energy is a safe and controlled renewable energy technology: present anywhere and available every time, independent of the season, climatic conditions and day time, use from antique time for heating & cooling!***

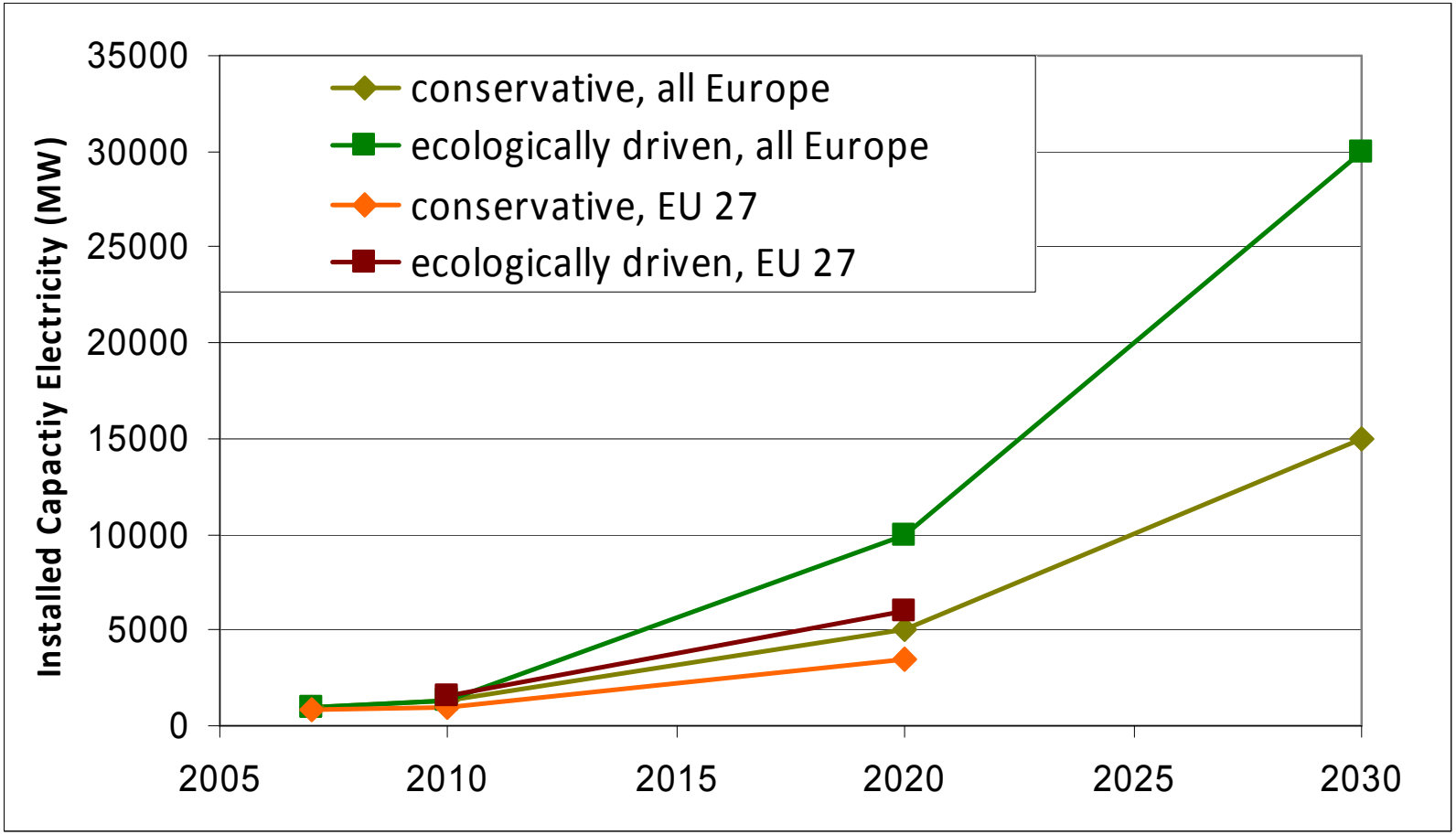
EGEC Brussels declaration 11 February 2009

- *> Until now we just used a marginal part of the underground heat reservoir potential. The most promising areas are the construction of new district heating networks (Geothermal district heating & cooling, with 50 €/MWh, is one of the most competitive energy technologies), optimisation of existing networks, and increased new and innovative applications of geothermal energy in transport, industry and agriculture.*

Geothermal power

Geothermal Power - EU-27	2000	2005	2010	2020
Conventional	0,812	0,829	0,910	1,2
Low enthalpy	0,013	0,014	0,069	0,300
EGS	-	-	0,010	4,5
Total : GWe	0,815	0,843	0,989	6
TWh		5,5	7	55

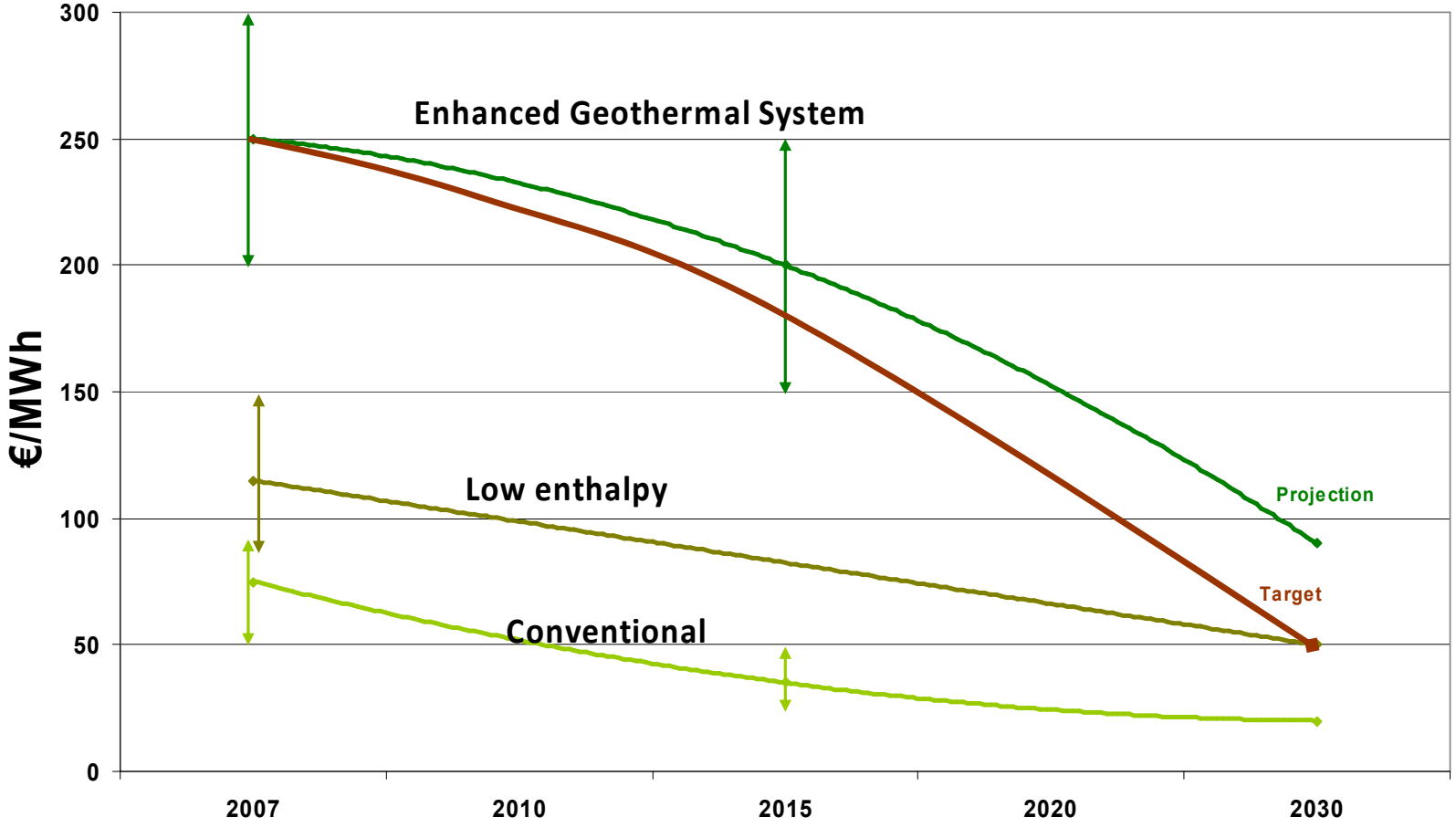
Geothermal power



Summary of targeted costs

ELECTRICITY	Costs 2007 Range(€/MWh)	Average (€/MWh)	Costs 2030 Average (€/MWh)
Conventional Geothermal Power	50 to 90	70	20
Low Enthalpy Production	80 to 150	115	Target: 50
EGS	200 to 300	250	Target: 50 Projection: 90

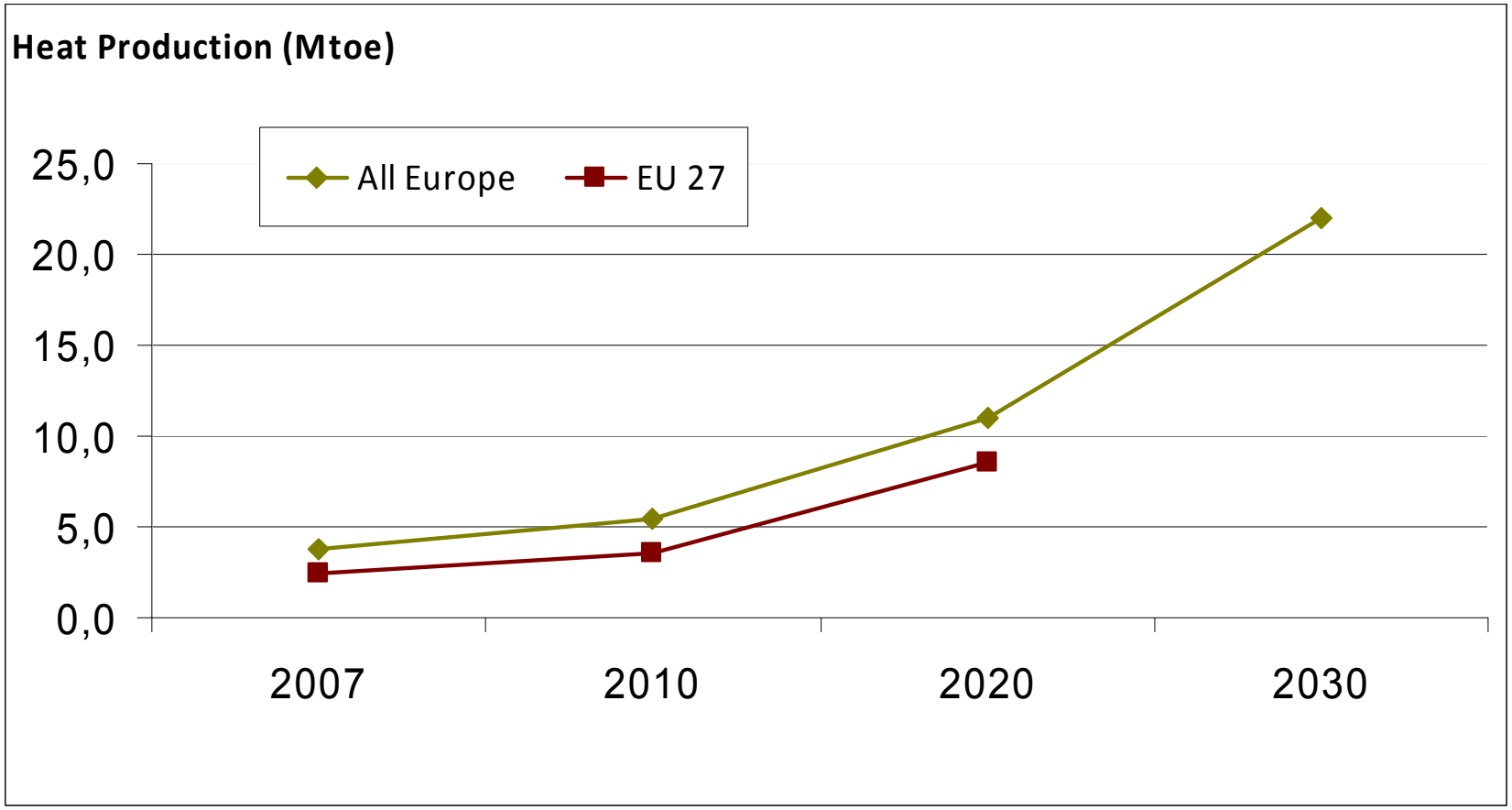
Geothermal power: unit cost



Geothermal heating and cooling

Geothermal h&c - EU-27	2007	2010	2020
Geothermal HP	1,4	2,5	6,2
Direct uses	1	1,2	2,3
Total : Mtoe	2,4	3,6	8,6
MWth	9 820	16 000	39 000

Geothermal heat production

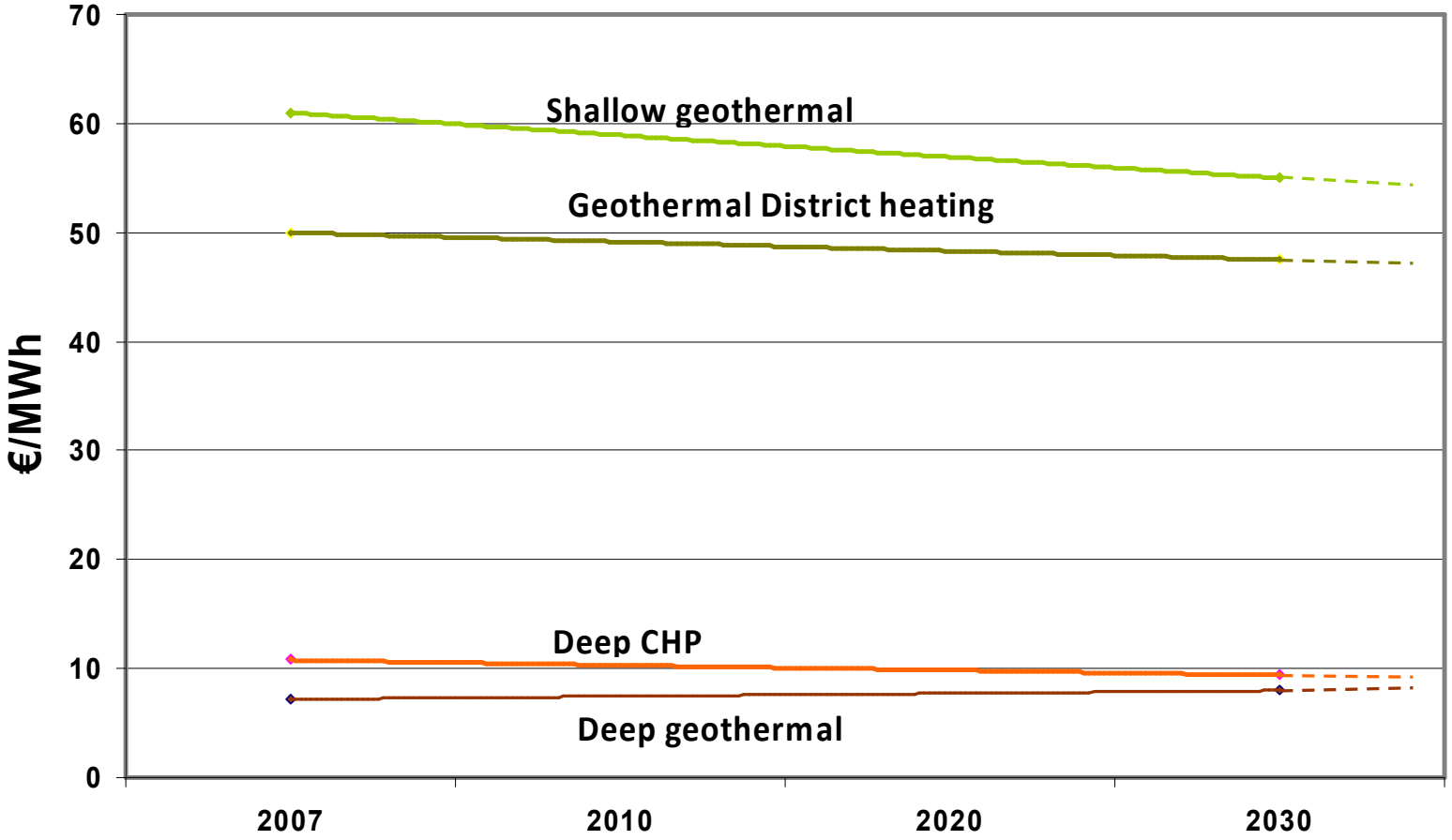


Summary of targeted costs

HEATING & COOLING		Costs 2005 Range (€/MWh)	Average (€/MWh)	Costs reduction by 2030 (% 2005 costs)
Deep geothermal		2 to 40	7,2	+11
District Heating[1]		40 to 80	50	-5
Shallow	Heat only	10,8 to 320	19	-9
	H&C: heating	7,2 to 270	61	-8
	H&C: cooling	7,2 to 350	16	-8

[1] The figures for deep and shallow geothermal are from the IEA report 2007: *Renewables for heating & cooling*. The data on District Heating are EGEC projections for geothermal DH in Europe.

Geothermal heating

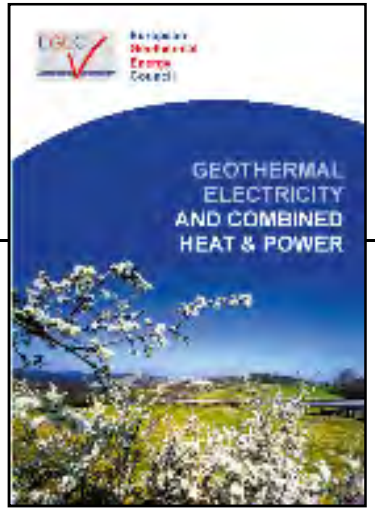


EGEC research agenda objectives

- In January 2009, EGEC published a geothermal research agenda fixing the research priorities for all geothermal technologies until 2030, in order to decrease costs:
  - by 5% for geothermal District heating: reach 40 €/MWh
  - by 10% for geothermal heat pumps: reach 15 €/MWh
  - by 30% for conventional geothermal power (flash and dry steam): reach 20 €/MWh
  - by 50% for low enthalpy production: reach 50 €/MWh
  - by more than 50% for EGS: reach 50 €/MWh

CONCLUSIONS

- Summing up, geothermal energy scored well in Europe and has huge potential.
- Geothermal energy should be a strong contributor to the EU objective of reaching 20% renewable energy share



Thank you for your attention!

For more information:

www.egec.org