LOW TEMPERATURE GEOTHERMAL APPLICATIONS AND PROJECTS IN SLOVENIA

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Geological survey of Slovenia

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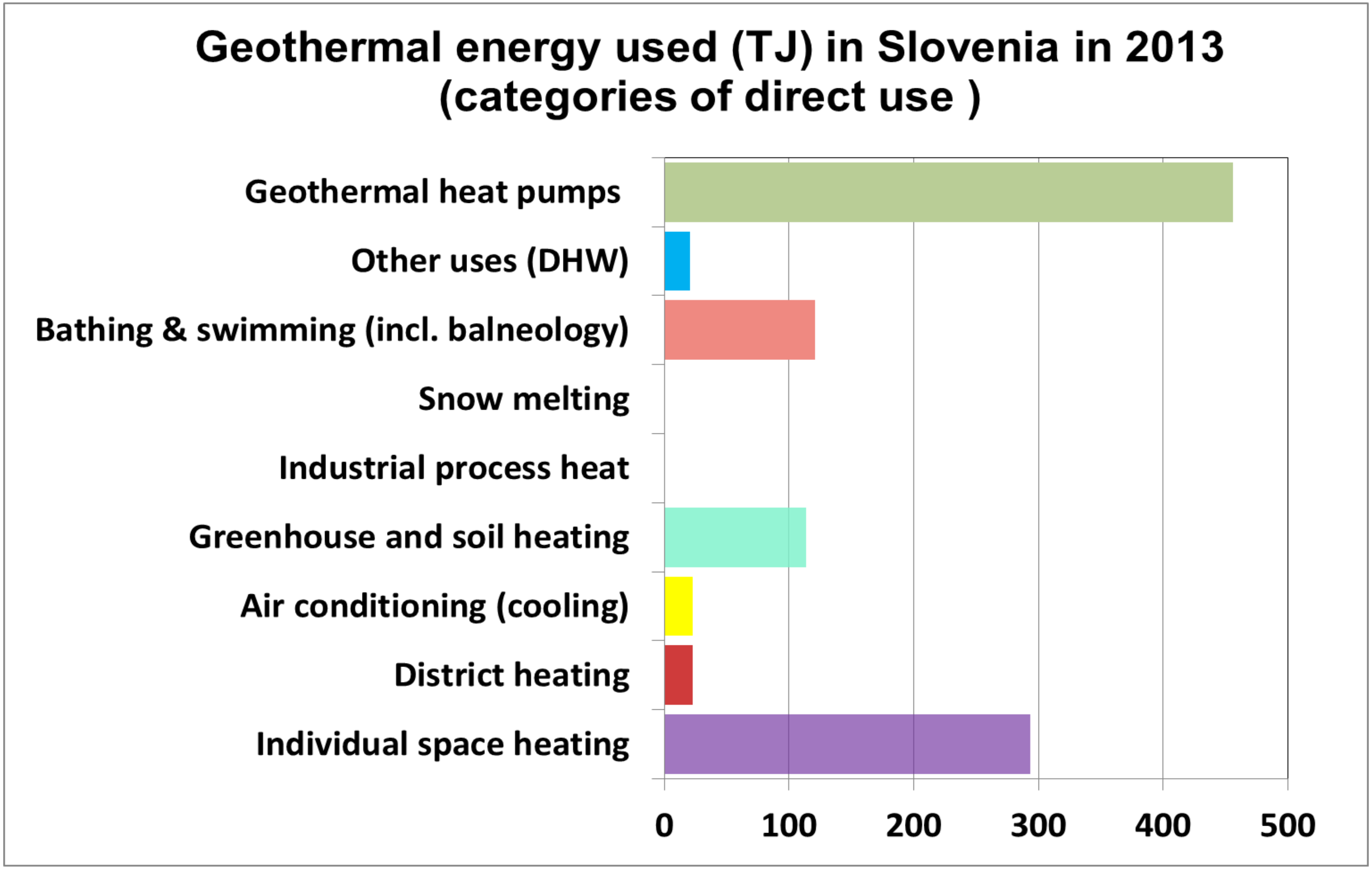
Geothermal energy use



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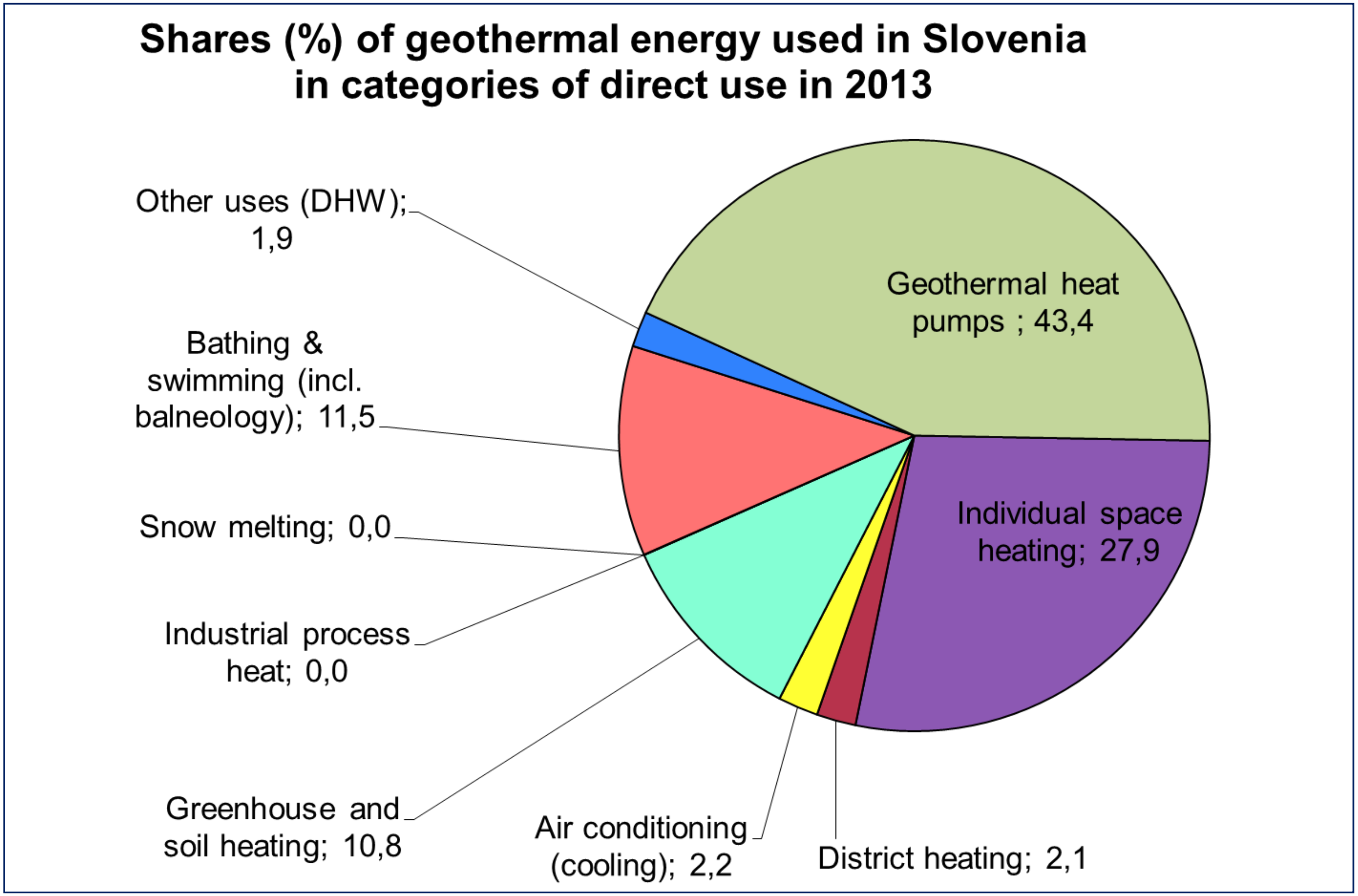
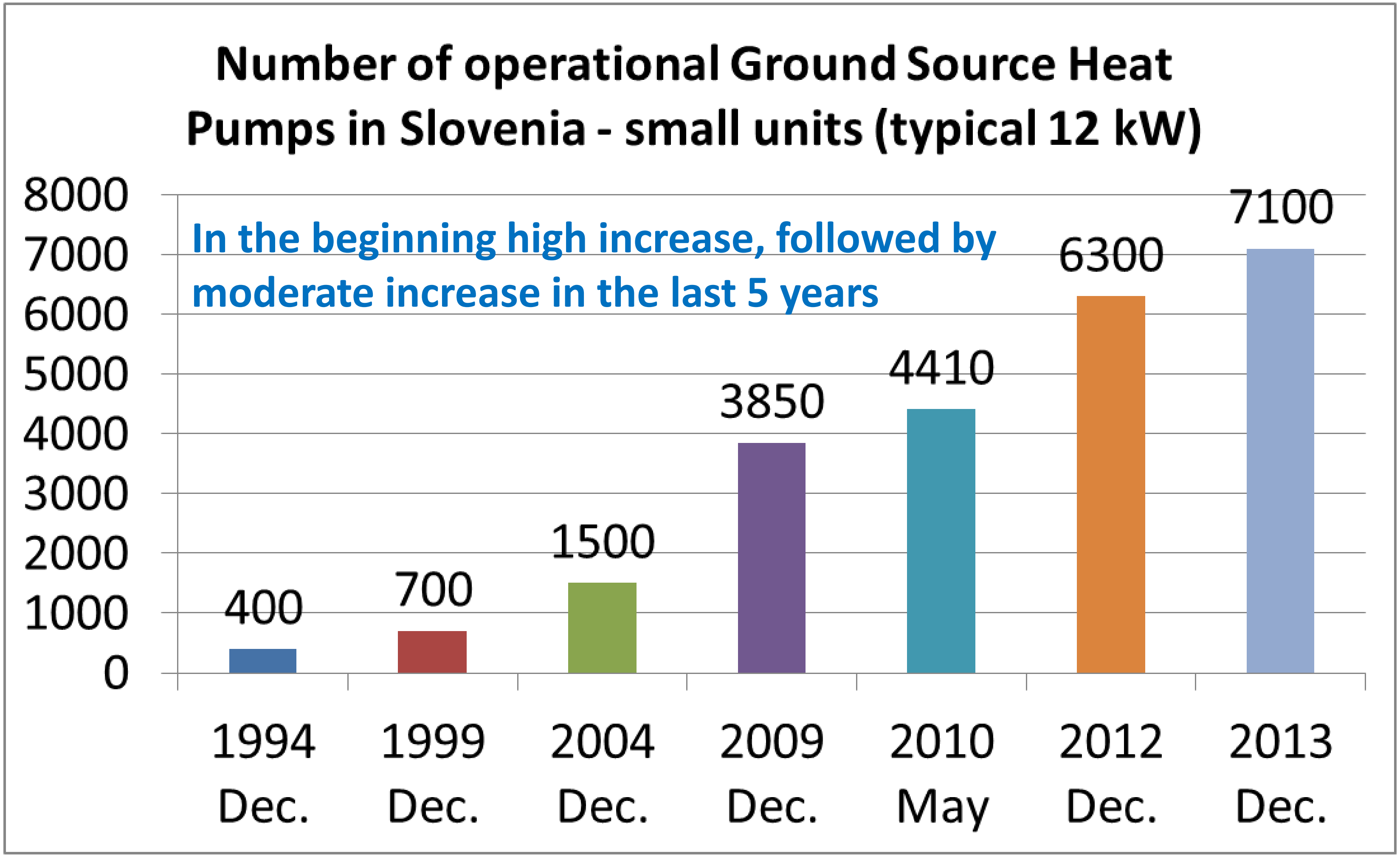
Quota of GSHP among all geothermal energy uses



Ground Source Heat Pumps in Slovenia

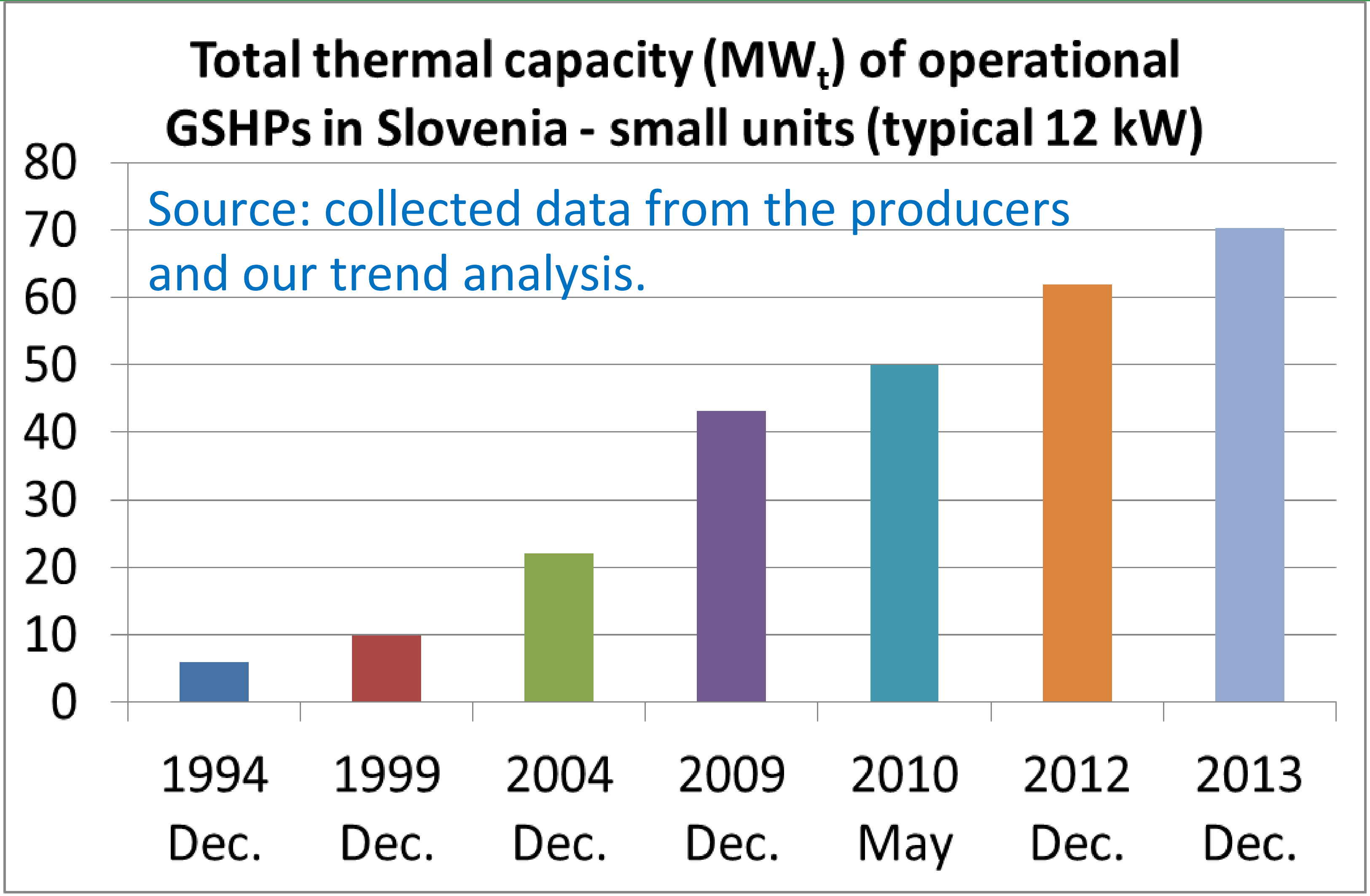


W - open loop water source (ca 52 %)

H - closed loop horizontal (ca 40 %)

V - closed loop vertical (ca 8 %)

Ground Source Heat Pumps in Slovenia



Geothermal energy used in 2013: ca 415 TJ (9.91 ktoe)

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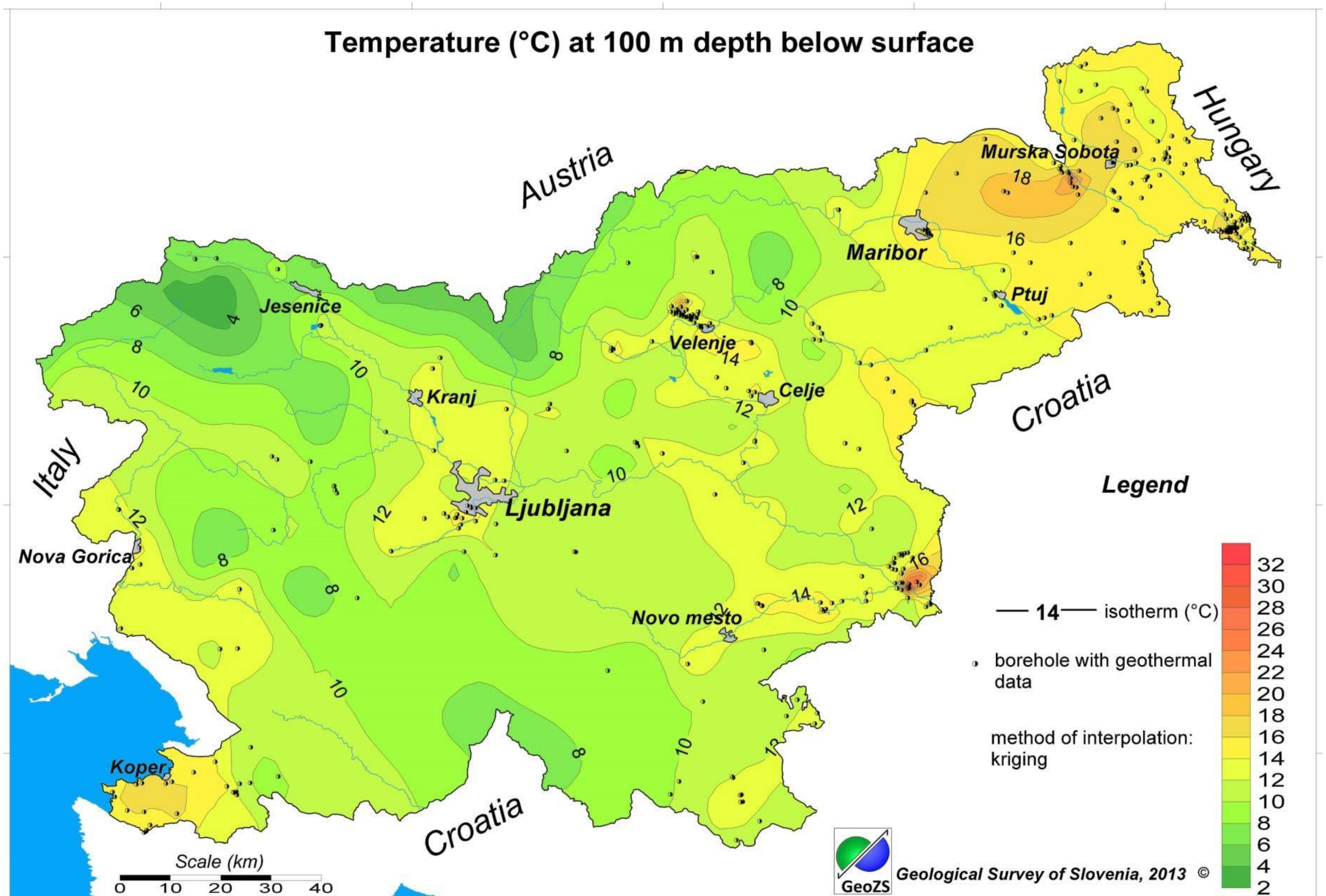
Ground Source Heat Pumps in Slovenia - Large systems

Large systems evidented up to date:	
Number:	54 facilities (33 W, 3 H, 18 V)
Typical capacity:	20 to 100 kW with maximum > 1,000 kW
Total HP rating or capacity:	11.34 MWt
Thermal Energy Used:	86.3 TJ/yr (2.06 ktoe)

Ground Source Heat Pumps in Slovenia - summary

- 43 % of geothermal energy utilized by GSHP.
- Reliable numbers of GSHPs for 1994, 2009-2010 and likely in 2014.
- Market growth (13 – 18 %) till 2008, later steady market.
- 4 main GSHP domestic producers & 2 – 3 small ones.
- Larger domestic producers are able to adapt to specific needs.
- Strong incentives for public buildings renovation in 2012/2013 initiated the use of HPs in significant amount.

Geothermal conditions at shallow depths



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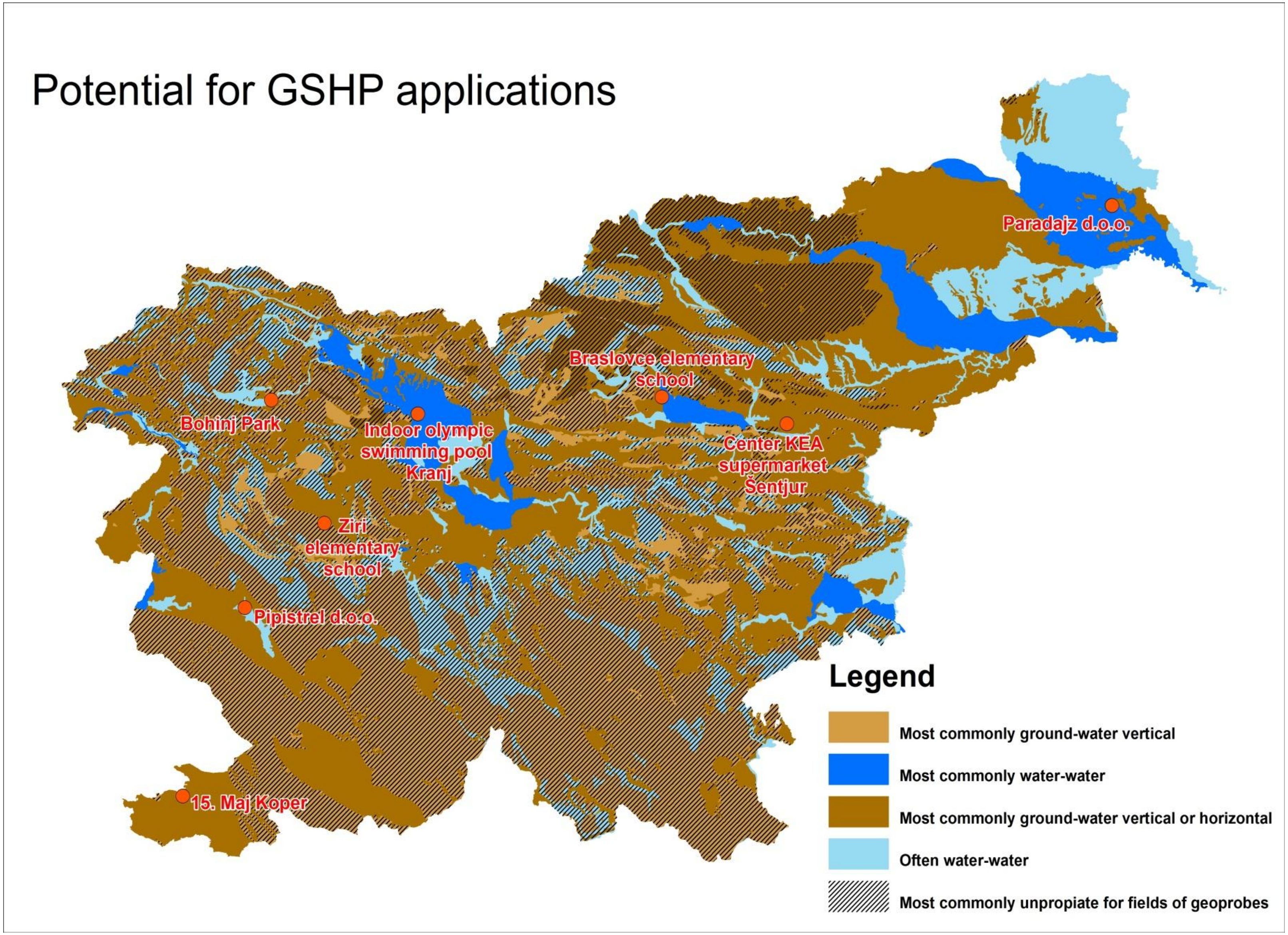
Sectors of applications of GSHP systems

- **Residential** (single family houses, villas, multifamily houses)
- **Recreation** (hotels, spas, farm holidays, swimming pools, sport facilities)
- **Agriculture** (greenhouses, wine cellars)
- **Public** (schools, kindergartens, theatres, libraries)
- **Commercial and industrial** (shopping malls, sheds)

Low temperature application examples



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Residential sector: The settlement “15. maj” in Koper

Geothermal (underground) parameters

- Soft mud silty soil in depths of ca 30 meters with possible flysch rocks (sandstone and marl) below.
- Estimated thermal conductivity: ca 1.9 W/(m·K) for silt, 2.4 W/(m·K) for flysch.
- Specific heat extraction rate: est. 45 to 50 W/m
- Underground temperature ca 12 – 15°C.
- Surface HFD of the area = 65 mW/m^2.

- 3 residential buildings: 67 apartments;
- 1 commercial bdg: offices, retail spaces
- Total area for heating: 8,800 m^2.

The settlement “15. maj” in Koper

System main features

- Reversible HP - 2 modules:
  - 200 kW (4 comp.) + 250 kW (5 comp.) heating power;
- 192 functional energetic foundation piles
  - 32 – 40 m depth, distance 4 m
  - 3-tube loops in each pile → 5 m of tubes/1 m pile.

- Amount of renewable energy ca 0.47 GWh
- Equivalent full load : ca 1500 h
- Electric power used: 163 kW, power of compressors: 51 kW
- SPFh 3.3 / SPFc: 5 to 5.5

Recreation sector: Bohinj Park EKO hotel - Aqua park

- **Geothermal parameters**
  - Water well BB-1/08 of 430 m depth,
  - Aquifer: dachstein limestone with dolomite inclusions of Late Triassic age,
  - Average outflow = 7 l/s with T = 13.7°C,
  - Wellhead pressure = 4 bar.
  - Surface HFD of the area = 36 mW/m^2

- **Heated net floor area**
  - Net: 11,500 m^2,
  - brutto: 15,000 m^2,
  - garage space (1,500 m^2) not included.

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Bohinj Park EKO hotel - Aqua park

- **System main features**
  - HP: 2 x 238 kW heating power, 2 x 170 kW cooling power.
  - Underfloor heating and heating/cooling beams.
- **Heating**
  - Equivalent full load hours: 1314
  - Amount of renewable energy supplied by HP technology: ca 0.766 GWh, with SPF 3.5
  - Use of electricity for Hotel and Aquapark: 1,940,000 kWh/yr
  - 40% of total electricity use is used for HP running, 20% is used for heating through HP.
- **Cooling**
  - Water from the well, after being used by the HP, flows cooled to the chilling beams.
- **Costs (savings)** : Up to 30% of primary energy with simultaneous production of heat and electricity.

Agriculture sector: Greenhouse Paradajz d.o.o., Renkovci

- **Geothermal parameters**

- Geothermal exploitation well Re-1g/11 with 1,485 m depth.
- Main geothermal aquifer: Mura fm (sand and silty sand, Pontian), Screen depth sections: 891 – 1475 m.
- Wellhead T = 58 – 65°C, Outlet T = ca 30°C.
- Surface HFD = 110 mW/m^2. Static Temp. and Pressure at 1475 m depth: 70.7°C, 148 bar

Greenhouse Paradajz d.o.o., Renkovci

- **System main features** (including energy parameters)

- Water pumped by submersible pump, flows to the plate heat exchanger, transfers heat to ordinary water that circulates in a closed system of pipes in the greenhouse, then cooled down discharged into the environment.
- $NaHCO_3$ type, mineralization 900 mg/l, little gas.
- Greenhouse surface = 4 ha for tomato production.
- Thermal energy is provided by geothermal and solar energy.
- During lowest temperatures greenhouses are heated also by natural gas. The CO_2 is used to promote photosynthesis.
- Waste heat also used and stored.
- Plan for reinjection of used thermal water into the Fi-5 well.

Greenhouse Paradajz d.o.o., Renkovci

- **Costs (savings)**

  - 1st phase: 6 mil. €, Investments in the greenhouse enlargement: 2.9 mil. €. About 40 % are covered by European funds.
  - Annual tomato production will increase to 3,000 t, it will cover 20 % of needs in Slovenia.

- **Scenarios of geothermal utilization**

Maximum Utilization			Capacity	Annual Utilization		
Flow Rate (kg/s)	Temperature (°C) Inlet	Temperature (°C) Outlet	(MW$_t$)	Ave. Flow (kg/s)	Energy (TJ/yr)	Capacity Factor
17	60	30	2,13	5	19,8	0,29
20	60	30	2,51	10	39,6	0,50
17	60	30	2,13	10	39,6	0,59
20	60	30	2,51	15	59,4	0,75
20	63	30	2,76	15	65,3	0,75

Public sector: Elementary school Braslovče

- **Geothermal parameters**
  - Quaternary sediments (clay, gravel, sand) and possibly Oligocene sediments (marly clay) below.
  - Estimated thermal conductivity: ≥ 2.1 W/(m·K) for sand-gravel with clay, ≥ 2.2 W/(m·K) for marly clay.
  - Specific heat extraction rate: 60 W/m.
  - Surface HFD of the area = 54 mW/m^2.
- **System main features** (including energy parameters)
  - HP 158 kW (2 x 79) heating, 20 BHEs: 100 m each, 5 m apart.
  - Total electric power = 39 kW.
  - COP = 4.05
- **Heated net floor area**
  - School & kindergarten: 4,800 m^2,
  - gym hall 1,000 m^2.

Elementary school Braslovče

- **Heating and DHW preparation**
  - SPF heating: 3.75
  - Equivalent full load hours for heating: 1800
  - Amount of renewable energy supplied by HP technology: ca 0.209 GWh, with SPF 3.75

- **Cooling**
  - The new system also allows for passive cooling of gym hall with convectors, or the whole school during the summer.

- **Costs (savings)**
  - Before the renovation the annual use of heating oil was 50,000 litres (or 504,000 kWh). Energy improvement investments: 230,700 €. Payback time: 5 years. Annual energy consumption should be reduced by 70%. (Source: VTV Magazine)

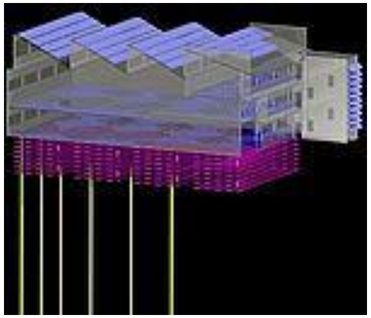
Commercial & Industrial sector: Pipistrel Research & Development building, Ajdovščina

- **Geothermal parameters**
  - Alluvial sediments (sand, clay, gravel) upper 30 m, Eocene flysch below (marl and sandstone, breccia, calcarenite and conglomerate).
  - Estimated thermal conductivity: 1.9 W/(m·K) for alluvial, 2.6 W/(m·K) for Eocene rocks.
  - Specific heat extraction rate: ca 70 W/m.
  - Surface HFD of the area = 35 mW/m^2.

- **System main features**
  - 6 BHEs with 200 m depth each
  - 14 to 15 kW / BHE.
  - HP unit: 35 kW heating p. with 3 hermetically closed compressors.
- **Heated net floor area**
  - The new building measures 2,400 m^2.

Pipistrel Research & Development building, Ajdovščina

- **Space Heating & Cooling**
  - SPF heating: 3.5.
  - Equivalent full load hours for heating: est. 1,500.
  - Amount of renewable energy supplied by HP technology: ca 0.039 GWh.
  - During summer space temp is cooled down to 15-17°C, during winter it is heated to 25-30°C (dT < 15°C).
  - Heating and cooling established in an innovative and efficient manner using ground radiation. This allows for the minimum possible temp. difference between highest and lowest water temperature in the building and yields maximum efficiencies and savings. The ground radiation system consists of a mesh of pipes made of high-density polyethylene PE-Xc. The temperature system of heated water is 35/25°C, in the summer 13°C.



Pipistrel Research & Development building, Ajdovščina

- **Costs (savings) and Main challenges**

- Thermal energy for heating in winter and cooling in summer is generated using vertical BHEs in conjunction with geothermal field to store energy. Electric energy is produced by the solar power plant, with a help of cogeneration units with fuel gas to cover all the needs of the facility's electricity.
- Geothermal accumulation field is a ground collector which functions as a storage for exchange and deriving of thermal energy at rate of 25 W/m^2. The capacity of the accumulation field measures 5000 m^3 and is placed underneath the whole building in form of 4 collectors each 250 m^2 in footprint.
- Solar power alone reduces their CO_2 emissions by 65,000 kg/year.
- Rough estimate of energy savings is 95,000 kWh/year, a total reduction of CO_2 emissions through the use of energy-saving systems amounts to 180,635 kg/year of CO_2 , it is less than if the building was built with conventional energy systems, which are now no longer used.

Large GSHP systems - summary

- More than 50 % of large systems are open loop (water to water).
- Mostly in alluvial aquifers, but also in dolomite rocks.
- Only few are horizontal GCHP.
- Largest BHE field: 24 boreholes with typical depth 100 m / Foundation construction: 192 energy piles.
- Large open loop systems: 8 abstraction wells.

Large GSHP systems - challenges

- Definition of the areas with the highest GSHP potential in spatial plans.
- Long term renovation strategy of buildings.
- Promotion of large systems.
- Promotion of combined energy sources systems and energy storage.
- Promotion of GSHP utilization in industrial facilities.

Recent GE projects in Slovenia

2007 - 2014	
Transthermal	Deep geothermal potential shared by SI – A.
T-JAM	Crossborder management of overexploitation issues, SI – HU.
Transenergy	Focused on PreTertiary reservoirs shared by SI – HU – A – SK: evaluated potential using supra regional and local models.
Groundmed	Demonstration GSHP system: 3 BHE and precise monitoring.
GeoPower	Action plan for GSHP market development.
Legend	Preinvestment analysis for GSHP in Adriatic region in coastal area of SW Slovenia.
GeoSEE	Innovative uses of low-temperature geothermal resources.

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THANK YOU FOR YOUR ATTENTION

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