Due to the diverse baseline data for the Cases Study Areas, qualitatively and quantitatively, HotLime decided to focus on the geothermal base assessment using a common applicable methodology which is less data demanding, rather than working on the application of a methodology that cannot be applied to most testbed areas due to a lack of data.

# Factsheet
# Volumetric Heat in Place

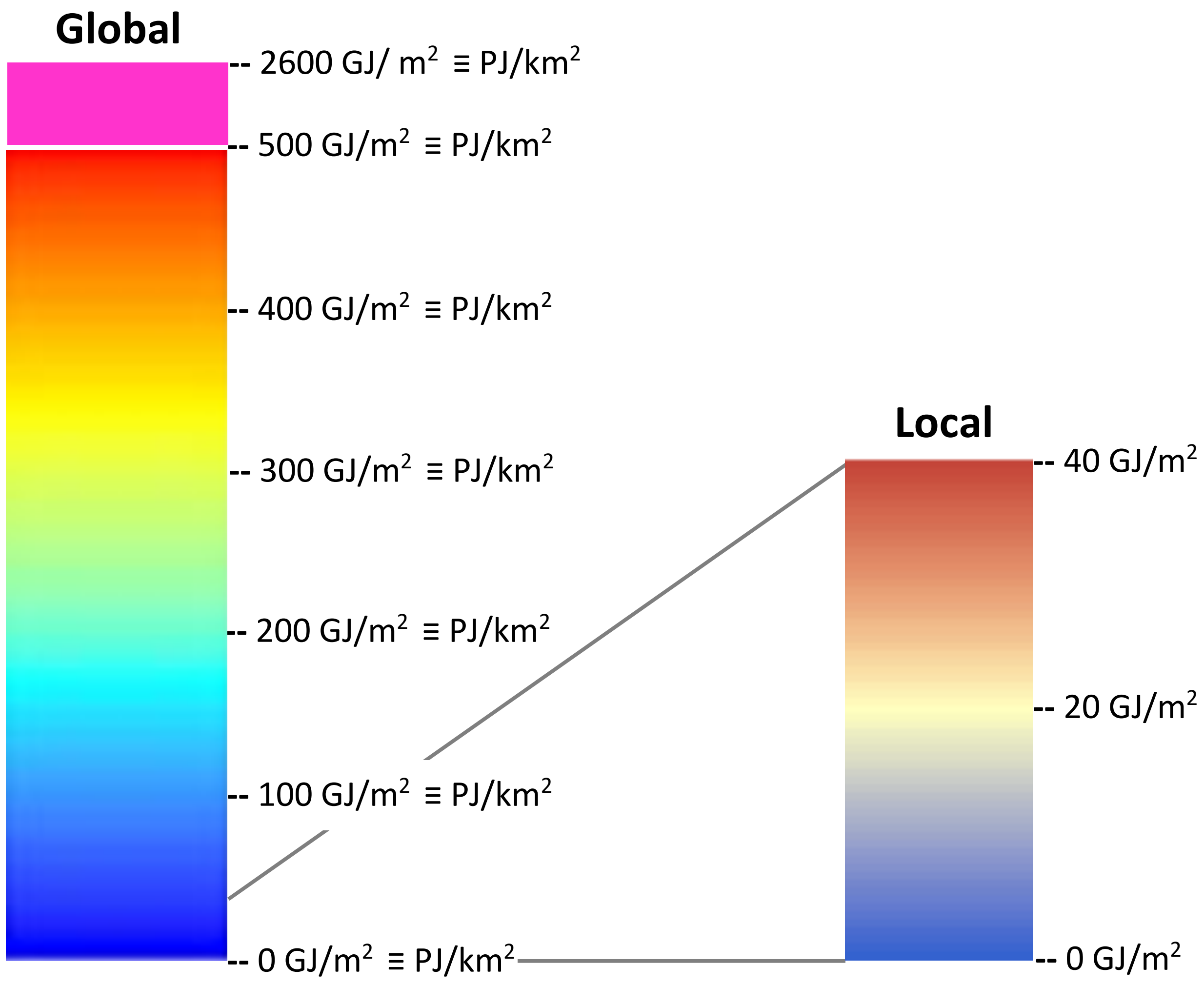
The measure heat in place (HIP) describes the maximum theoretically extractable heat from the reservoir and represents a basis for further estimating the resource potential in a geothermal reservoir. The volumetric 'Heat in Place' (HIP) method, developed by the United States Geological survey (USGS) and reported by Muffler & Cataldi (1978), with subsequent revisions and reformulations (Williams et al. 2008, Garg & Combs 2010, 2011, 2015), is the most globally used evaluation technique to estimate the available heat from deep geothermal reservoirs among geological services, research centres and companies in general. A HIP estimation is the first and the key step of any geothermal project in early exploration stages. This method calculates the heat in energy per unit area (usually in $GJ/m^2$), which is present in a geothermal aquifer, with respect to an arbitrary cooling temperature which is usually set to surface or ambient temperature. The method requires estimates on reservoir depth and thickness, temperature, and the reservoir rock properties specific heat, density, porosity, and water specific heat and density. The thermal energy $Q_{total}$ stored in a homogenous volume of rock is expressed by the equation:

$$Q_{total} = [(1-\phi)c_{pr}\,\rho_r+\phi c_{pw}\,\rho_w\,]*h*(T_r-T_{ref})$$

The table below lists the parameter values required for the application of the equation. The common parameter values that were adopted in order to achieve HIP values that can be compared across pilot sites, are marked in grey. The area specific variables derived from mapping and characterisation of the reservoirs (see HotLime Deliverable 2.0) are marked in yellow.

| | description | unit | value |
|---|---|---|---|
| $Q_{total}$ | energy content for a column of reservoir rock | $J / m^2$ | |
| $\phi$ | bulk porosity | fraction | 0.05 |
| $c_{pr}$ | specific heat capacity for the carbonate reservoir rock (matrix) | J / kg.K | 860 |
| $c_{pw}$ | specific heat capacity (water) for the pore fluid (brine) | J/ kg.K | 3800 |
| $\rho_r$ | rock matrix density of carbonate rock | $kg/m^3$ | 2700 |
| $\rho_w$ | density of low TDS water at about 100°C | $kg/m^3$ | 1040 |
| h | reservoir thickness | m | - |
| $T_r$ | average reservoir temperature | °C | - |
| $T_{ref}$ 18 | reference (re-injection) temperature *) | °C | 18 |
| $T_{ref}$ 50 | reference (re injection) temperature **) | °C | 50 |
| *) | ambient + 10°C, adopted from Limberger et al. (2018) for the worldwide comparison | | |
| **) | average re-injection T after power generation and/or heat production | | |

The colour key “global” is designated for the comparability of all case study areas, whilst colour key “local” provides a higher-resolution for case study areas featuring a HIP < 40 GJ/$m^2$.




Heat in Place calculated for $T_{ref}$ 18 ($HIP_{18}$), based on reservoir volume units of 500 x 500 x gross-thickness [m] and expressed in GJ/$m^2$, is portrayed for all testbed areas in the HotLime Geo-thermal Atlas. For $HIP_{50}$ and further area specific HIP assessments, as well as the including the spatial distribution and variations of the site-specific parameters, see HotLime Report 3.1.

Due to higher porosities ϕ, thus a higher fraction of pore fluid, fault zones may feature a considerably higher HIP, which is not quantifiable without detailed knowledge of the fault characteristics. The fault network overlay, however, provides qualitative information on these zones of probably higher geothermal prospectivity (cf. Factsheet Faults).

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