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Geothermal Potential Catalog Update for the Bánovská kotlina Basin, Slovakia: Estimating the Total Thermal, Sustainable and Developable Geothermal Potential Combining Probabilistic Resource Assessment Approach with Real Production Data

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ABSTRACT

The paper presents combination of stochastic thermal catalog model with real production data to address developable potential at Bánovská kotlina Basin and possibilities to introduce a geothermal segment into hybrid district heating system of the town of Partizánske. The probabilistic thermal potential at 50 % risk rate counts TTP(p) = 13 MWt for sustainable (t_{prod} = 100 years) and TTP(p) = 31 MWt for short-term (t_{prod} = 40 years) production. Setting the 50 % of total thermal potential a critical sustainable capacity level corresponding to a reserve capacity ratio rcap = 0.5, the sustainable potential is assumed for $Pth_{(S)}$ = 6 MWt and $Pth_{(S)}$ = 15 MWt respectively. Production history (2011 – 2024 period) curve indicates a cumulative mean monthly thermal output at $Pth_{(REF)}$ = 0.3 – 1.3 MWt if referenced to T_{ref} = 15 °C, i.e. $Pth_{(REF)} < Pth_{(S)}$. Then, normalized thermal output of $Pth_{(REF*)}$ = 1 MWt yields developable potential of $Pth_{(D)}$ = 5 MWt and 13 MWt respectively.

1 INTRODUCTION

The Bánovská kotlina Basin (BKB) was identified as a perspective geothermal area in the mid 80's, assuming 63 MWt of probable reserves, applying the USGS volume method to mean borehole data (Fendek et al., 1986). Recently, deep geothermal resources have been proven in Bánovce nad Bebravou (1), Topoľčany (1), Brodzany (1), Partizánske (2) or Malé and Veľké Bielice (3), along with several epithermal springs at the Bielické slatiny site. Cumulative proven reserves nowadays count 5,6 MWt equal to 63,7 $l.s^{-1}$ yield.

As of 2024/2025, a new geothermal catalog for 31 geothermal water bodies in Slovakia was finished, based on conceptually guided, and conditioned probabilistic simulations using the USGS volume method and the recovery factor assessment. The catalog is believed to replace understanding of geothermal potential in the country since Atlas of Geothermal Energy of Slovakia (Franko et al., 1995). Although its scope is to identify a total thermal and sustainable potential, it also covers solution of past drawbacks, such as inconsistency in application of assessment methods, mixing different production time scales, use of constants for the recovery factor setting, or substitution of discrete values given by (typically) insufficient number of wells per total reservoir area (Fričovský et al., 2024).

Given by a strategic development plan of the city of Partizánske, the municipality calls to promote its current natural gas district heating system towards a hybrid-type, including NG, shallow and deep geothermal resources and biomass. Answering a geothermal potential for sustainable reservoir operation, and, thus, development not compromising a sustainable reservoir capacity in terms of its future extended production, is among key scopes of the PSK-MIRRI-018-2024-DV-FST „Integrating the sustainable reservoir management and advanced control systems to introduce low-enthalpy geothermal resources for the geothermal district heating system of the Partizánske city" project.

2 GEOTHERMAL PLAY DESCRIPTION

The BKB is a typical Neogene-formed intramountain depression with structural delineation to surrounding mountains, i.e. Tríbeč (E), Považský Inovec (E) and Strážovské vrchy (NW, N). According to the play-type concept (Moeck et al., 2019), it is identified as conduction-dominated (CD), adjacent orogenic belt-type (CD2b), regionally (Fričovský et al., 2023, 2024) classified as intramountain depressions (CD2bb).

2.1 Geological settings

A total delineated area of the BKB is approx. 558 km^2 (Marcin et al., 2020). Due to Cenozoic tectonics, the reservoir unit is, however, limited to 398 km2 as identified by limited geophysics (e.g. Fendek et al., 1986; Remšík et al., 2007). For the purpose of conceptually guided and conditional modeling, the play is described through following complexes (Fig. 1).

2.1.1 Top insulator – Cenozoic basin fill (IZO1)

The basin fill consists of Neogene pelites-dominated strata intercalated with thin sandstones and rare conglomerates, and relics of the Inner Wester Carpathian Paleogene at the base of basal conglomerates and pelitic and flysch-type sequences. Overall complex thickness varies $\Delta z_{(IZO1)}$ = 190 – 2,900 m; neglecting few meters thick Quaternary cover, reaching local maxima in local Držkovce depression (Remšík et al., 2007).

2.1.2 Shallow reservoir unit – Hronicum nappe series (RES1)

The shallow reservoir unit consists of two Mid Triassic – Late Triassic carbonates-dominated complexes, separated on tens-meters thick claystones and shales of the Lunz Beds. According to geophysics and borehole data, the thickness varies $\Delta z_{(RES1)}$ = 80 - 800 m, radially increasing in W – E direction. (Remšík et al., 2007; Fričovský et al., 2024). According to the model, the reservoir base is at z = 400 – 3,200 m. Unlike top insulator, this unit is limited to the W and SW basin periphery.

2.1.3 Uncertainties in deep geological structure

The model terminates with the RES1 unit at the base (Fričovský et al., 2024). In fact, the FGTz-1 Topoľčany well (Fendek et al., 1986) intercepted the Tatricum Cover Unit, i.e. Mesozoic series in para-autochthonous position to the crystalline bedrock. Examples from analogous intramountain depressions of the Western Carpathians show, moreover, typically Fatricum nappe series beneath RES1, yet with no data within BKB.

2.2 Review on hydrogeothermics

2.2.1 Heat flow distribution

A surface heat flow density varies q_S = 67 - 70 mW.m^{-2}, with a mean of q_S – 69 mW.m^{-2} compared to a mean q_S = 70 ± 14 mW.m^{-2} in the Western Carpathians (Fričovský et al., 2024), ranking BKB as of moderate activity. Because of conduction-dominated system, the $q_{(IZO1)}$ = 64 – 69 mW.m^{-2} drops with top insulator geometry.

2.2.2 Steady-state reservoir temperatures

For the conduction-dominated steady state conditions, the reservoir is modeled for $T_{(T,RES)}$ = 18 – 106 °C with a mean of $T_{(T,RES)}$ = 44 °C at its top in z = 190 – 2,900 m. With respective thickness and calculated conductive geothermal gradient of 18 – 25 °C.km^{-1}, the temperature increases to $T_{(B,RES)}$ = 25 - 112 °C with a mean of $T_{(T,RES)}$ = 53 °C at the base in z = 400 – 3,200 m. Temperatures greater than 80 °C are, however, modeled within the Držkovce depression only (Fričovský et al., 2024).

2.2.3 Hydrogeochemistry

Geothermal waters (wells and springs) sampled in BKB are typically of carbonatogene (Ca-Mg-HCO_3) type, relative with the Mid – Late Triassic carbonates of the Hronicum domain. The TDS = 350 – 1,800 mg.L^{-1} is typical for shallow and fast circulation regimes in hydrogeothermal systems of the Western Carpathians. Since c(SO4) = 10 – 135 mg.L^{-1}, whose sources are Late Triassic evaporites of the Fatricum nappe series, any contact with the deep reservoir body is questionable. The only exception is FGTz-1 Topoľčany well (Fendek et al., 1986), where low enthalpy geothermal waters hosted in both, Cenozoic basin fill and Mid Triassic carbonates of the cover unit are rather mixed. While the TDS = 4,700 – 6,500 mg.L^{-1}, there is also a rapid increase in sulphate - c(SO4) = 900 – 1,600 mg.L^{-1} equal to r(SO4) = 18 - 27 mmol.z %. This implies slow and deep circulation system later mixed with shallow waters with likely provenience in IZO1 complex.

3 HYDROGEOTHERMAL POTENTIAL – A GUIDED PROBABILISTIC APPROACH

A conceptually guided and conditioned approach in probabilistic simulations applied to construct the catalog of national geothermal potential relies on: 1) setting simulation ranges according to geological, hydraulic and geothermal model data; 2) adjusting R0 assessment method to reservoir hydrogeological regime – i.e. effective volume method (e.g. Sanyal – Buttler, 2005) for open, and production efficiency method (e.g. Ungemach et al., 2005) for closed-reservoirs or with mandatory reinjection; 3) processing and post-processing of simulations for both, the R0 and H_T, i.e. use of single 10,000 iterations for single, layered and hydraulically connected reservoirs, while setting multiples of 10,000 simulations per each stratified reservoir unit with no connection, thermal or

hydraulic, to other; 4) setting area constant for systems expecting reinjection or as a dynamic variable for open to simulate effect of potential production area reduction due to natural recharge or expected cooling at reservoir peripheries; 5) priorizing effective / prospective area definition through anomaly hunting concept following surface heat flow anomalies → reservoir top heat flow anomalies → reservoir top temperature anomalies → reservoir top temperature percentile distribution selection criteria; and 6) opting for short-term (40 years) and long-term / sustainable production period (100 years) for each modeled geothermal water body. In case of BKB, the guided approach calls a single 10,000 iterations per both, the R0 and H_T (single-reservoir model), use of a total area as dynamic variable and effective volume method (reservoir system considered open in general).

3.1 Recovery factor

3.1.1 Effective volume method

The recovery factor represents portion of energy stored in a reservoir that is available for production under current or expected (natural, legal, technical) near-future conditions (e.g. Garg – Combs, 2011). The effective volume method (e.g. Williams, 2004) modified to map for local heat flux / reservoir temperature anomalies, simulates extension of most prospective reservoir sections – Ve, compared to a bulk reservoir volume (including recharge and downstream transition zones) – Vt, applied to a difference between natural and technical conditions. While the first are given by reference temperature, the latter are set according to a tolerated cooling rate, i.e. 10 % compared to initial conditions (e.g. Fox et al., 2013).

3.1.2 Model procedure

According to geothermal catalog construction approach, the procedure (Fig. 2) follows: 1) conditioned setting simulation PDFs; 2) obtaining primary population given by 10,000 iterations of effective volume method simulation; 3) a first subpopulation selection according to P90(R0) – P50(R0) range from the primary population; 4) subpopulation test for normality towards dynamic model at given mean and standard deviation; 5) repeated simulation with 10,000 iterations; 7) application of the model to the USGS volume method

3.1.3 Recovery factor assessment

Substitution of data listed in Table 1 into effective volume method equation obtains R0 = 0.001 - 0.999 range for primary population, with a mean of R0 = 0.152 and P90(R0) = 0.031, skewed right. This range is opted for lognormal simulation model according to normality test, with a mean of R0 = 0.065 (Fig. 2). This is less than a mean R0 = 0.095 as of R0 = 0.015 – 0.35 GWB range according to national catalog (Fričovský et al., 2024). This correlates with a low geothermal activity and extended recharge and downstream transition zones of the reservoir to the south and west, including expected compaction in the central Držkovce depression.

3.2 Geothermal potential assessment model

3.2.1 USGS volume / heat-in-place method

The USGS heat-in-place approach (Muffler and Cataldi, 1978; Garg and Combs, 2015) is one of the most applied in geothermal assessment among the power density or magmatic heat budget method (e.g. Ciriaco et al., 2020). Under local geothermal conditions, only a single-phase geothermal water is expected as a resource, opting to assess for rock / matrix "r" and water / fluid "w" component in terms of natural gradient between reservoir (T_{res}) and reference (T_{ref}) conditions (Fig. 2) for the reservoir volume at variable area At.

3.2.2 Total and recoverable stored heat balance

A procedure in construction of the geothermal potential assessment model is described in Figure 2:

1) the total heat stored H_T is simulated applying Monte Carlo simulation to the USGS volume method given by set PDFs according to the Table 1. With N = 10,000 iterations, the total heat stored is assessed for H_T = 1.83 – 8,070 PJ with a mean of H_T = 821 PJ, skewed right;

2) the H_T compensates with the R0 LN distribution model to yield recoverable heat H0 as energy available for production. The recoverable heat counts H0 = 0.08 – 634 PJ with a mean of H0 = 56 PJ and a P50(H0) = 40 PJ. The high skewness Y(H0) = 3.1 is likely due to LN R0 distribution, as well as due to relatively shallow reservoir geometry with the only exception at the Držkovce depression (Fig. 1).

3.2.3 The stochastic McKelvey scheme model

Construction of geothermal potential catalog combines adapted McKelvey scheme (Williams et al., 2010) with the geothermal reserves booking concept (Sanyal and Sarmiento, 2005). The scheme is modified adding the total

thermal potential – TTP(p) as a thermal potential at a 50 % probability rate, i.e. TTP(p) = P50(E0) corresponding to a critical risk rate (Fričovský et al., 2024). The procedure (Fig. 2) is straightforward:

1) the recoverable heat in place H0 is balanced to t_{prod} = 40 years (short-term period) and t_{prod} = 100 years as a base understood a sustainable (e.g. Axelsson et al., 2001); yielding E0 = 6 – 138 MWt and E0 = 2 – 55 MWt at a 90 % confidence interval respectively (Figure 2);

2) definition of McKelvey scheme classes according to obliged (Sanyal – Sarmiento, 2005) percentile ranges;

The probabilistic McKelvey scheme is presented in Table 2. According to actual database (see current CU for Slovakia) proven geothermal reserves count Rpv = 5.6 MWt at respective deliverability of Qpv = 64 $l.s^{-1}$. The balance for a short-term production period yields probable reserves of Rpb = 23 MWt at 63 % confidence rate, while probabilistic total thermal potential is TTP(p) = 31 MWt. This is, however, roughly 1 % (TTP(p) = 5,500 MWt) on a total thermal potential quantified for Slovakia. The geothermal potential drops with time as the load on energy balance increases, except proven reserves. While probable reserves reduce to Rpb = 9 MWt (62 % probability rate), the probabilistic total thermal potential is assessed for TTP(p) = 13 MWt. The proportion on a TTP(p) for geothermal resources in Slovakia keeps at 1 % (TTP(p) = 2,204 MWt). There are, however, uncertainties to consider in onward geothermal developments:

a) geothermal wells have never been tested simultaneously, i.e. proven reserves are at least questionable in the vicinity of the Partizánske town, targeting likely the same hydrogeothermal structure

b) although the model is constructed for the shallow geothermal reservoir in the Hronicum nappe series, existence of deep reservoir in Mid Triassic carbonates of Fatricum or Tatricum Cover Unit is very likely; geothermal potential model update relies then upon their hydraulic / thermal communication (separate simulations for none, a joint simulation for connected), consequently expecting changes after targeting.

4 RESERVOIR SUSTAINABILITY AND PRODUCTION DEVELOPMENT

Geothermal energy is expected to grow in Slovakia, due a need to diversify energy supply and increase the energy security; and EU-funded schemes for drilling, exploration or hydrogeothermal evaluation. For long, discussion on sustainable reservoir production has been limited only to deliverability. Even national legislation focuses on sustaining flow rates when applying for withdrawal permits (e.g. Fričovský et al., 2020). The national geothermal catalog approaches a question of reservoir production sustainability combining reservoir limits through a sustainable reservoir capacity – $Pth_{(S)}$ and production boundaries termed sustainable development potential – $Pth_{(D)}$.

Table 1. List of input parameters and PDFs setup for R0 and geothermal potential simulations

parameter	unit	min	max	ave	med	ml	PDF function
A_t for R0	km^2	398	398	n/a	n/a	n/a	constant
A_t for USGS	km^2	86	398	n/a	n/a	320	Δ left
A_e	km^2	12	86	n/a	n/a	28	Δ right
Δz	m	83	800	336	302	275 / 775	bimodal
$Δz_e$	m	106	317	n/a	n/a	237	Δ left
$z_{(DP)}$	m	330	3,270	1,213	1,1100	850 / 2,950	bimodal
$z_{(DP)e}$	m	1,040	3,270	2,065	2,024	2,050 / 2,950	bimodal
$T_{res,i}$	°C	12	125	77	76	33 / 107	bimodal
T_{cool}	°C	-	-	-	-	-	function of $T_{res,i}$
$\phi(z)$	-	-	-	-	-	-	function of $z_{(DP)}$
$\phi(z)_e$	-	-	-	-	-	-	function of $z_{(DP)}$
ρ_w	$kg.m^{-3}$	-	-	-	-	-	function of $T_{res,i}$
c_w	$J.kg^{-1}.K^{-1}$	4,200	4,200	n/a	n/a	n/a	constant
ρ_r	$kg.m^{-3}$	-	-	-	-	-	function of $\phi(z)$
c_r	$J.kg^{-1}.K^{-1}$	-	-	-	-	-	function of ρ_r
T_{ref}	°C	15	15	n/a	n/a	n/a	constant

Table 2. Bánovská kotlina Basin – probabilistic McKelvey scheme model

McKelvey scheme	Symbol	t_{prod} = 100 years	t_{prod} = 40 years	P(E0) scaling
Total geothermal resources	R_{ST}	552	1,385	P5(E0)
Total geothermal reserves	R_{ET}	43	98	P10(E0)
Inferred (possible) reserves	Rinf	28	70	P10(E0) – P50(E0)
Total thermal potential	TTP(p)	13	31	P50(E0)
Probable reserves	Rpb	9	23	P90(E0) – P50(E0)
Proven reserves	Rpv	5.6		-
Recovery factor model	R0	0.031 – 0.152		

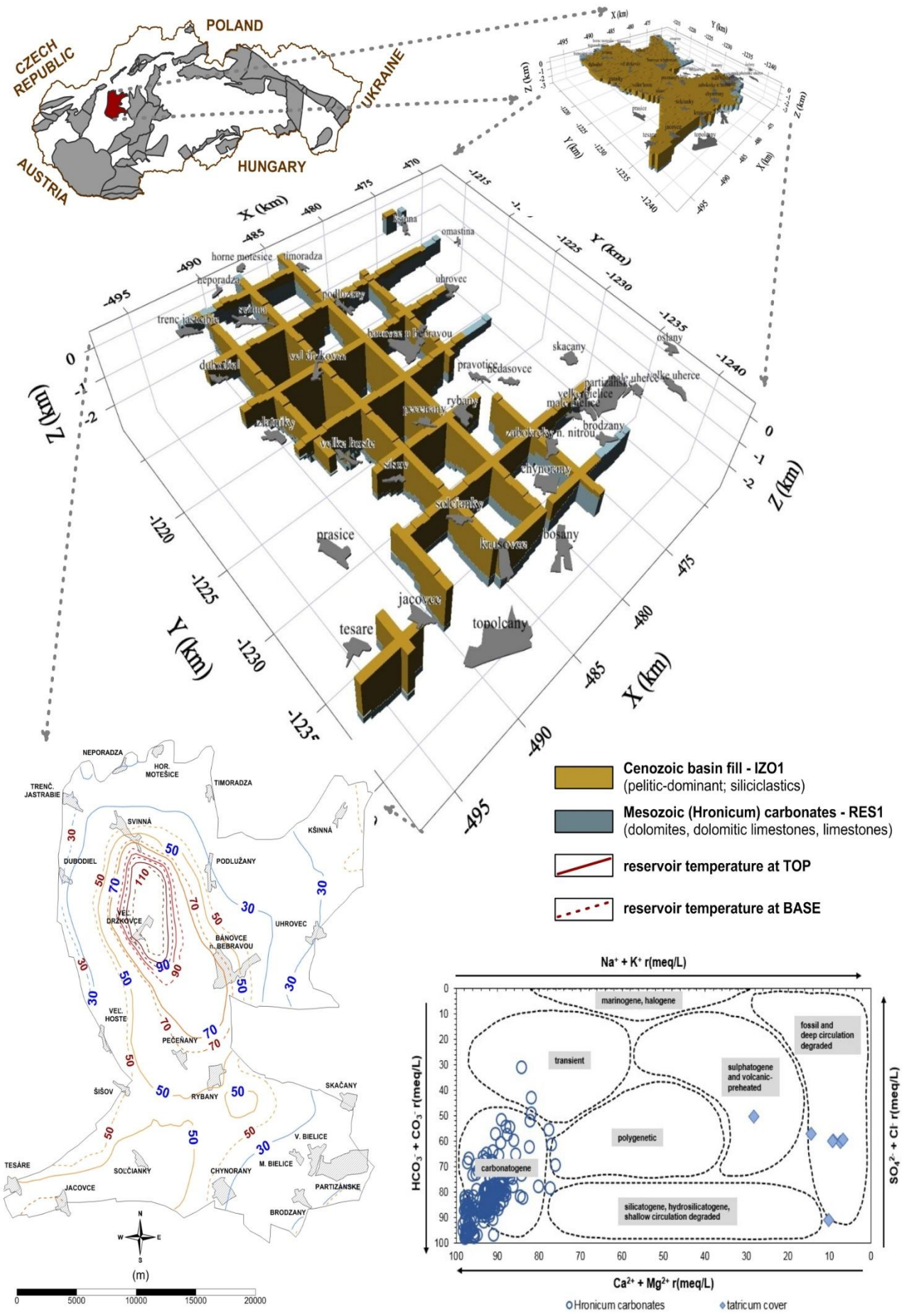


Figure 1. Bánovská kotlina Basin – geological structure, reservoir temperatures and Piper plot.

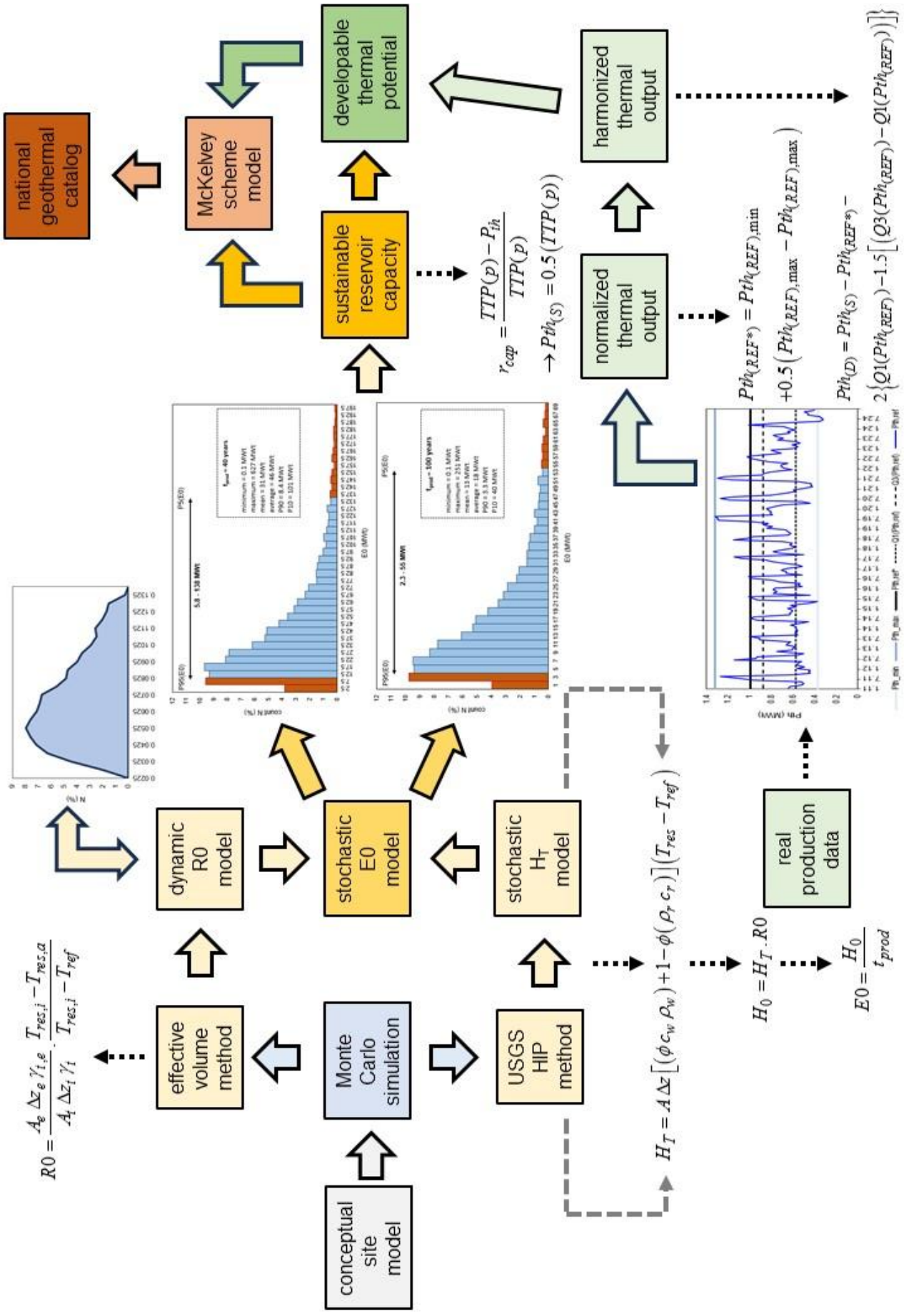


Figure 2. Bánovská kotlina Basin – geothermal potential catalog model workflow.

4.1 Sustainable reservoir capacity model

The sustainable reservoir capacity for every GWB in Slovakia is approached through the reserve capacity ratio (Bjarnadottir, 2010; Fričovský et al., 2020), i.e.:

1) analogously with official reserve capacity ratio – r_{cap} definition, the critical sustainable level of reservoir production equals 50 % of its reservoir capacity linked to probabilistic total thermal potential TTP(p) in the catalog, so that $Pth_{(S)}$ = 0.5 × TTP(p) or $Pth_{(S)}$ = 0.5 × P50(E0)

2) substitution of TTP(p) = 31 MWt and TTP(p) = 13 MWt yields the sustainable reservoir capacity of $Pth_{(S)}$ = 15 MWt and $Pth_{(S)}$ = 6 MWt for a short- and long- term production period respectively.

Although use of energy-balance method cannot compensate for a continuous and complex reservoir monitoring and reservoir response modeling, it may, however, be useful on a basin-scale and in terms of a production development control, where relevant reservoir monitoring data are missing, including history-matching. For early development stages, setting a reservoir capacity limit minimizes risk of depletive operation capable to cause changes in reservoir dynamics, thermal regime and reservoir chemistry.

4.2 Reservoir production in 2011 – 2024

A key scope of the model is to search for sustainable development options for the BKB on a basin scale, while on a local scale, the cited project plans to conduct a long-term simultaneous pumping tests and monitoring at the Partizánske / Malé Bielice site. The catalog considers a production history as of 2011 – 2022, however, to search for most precise data, the production history was set for 2011 – 2024.

Recently, there are 4 wells online, the BnB-1 Banovce nad Bebravou (Qpv = 17 $l.s^{-1}$, T_{wh} = 40 °C, $Pth_{(INST)}$ = 1.7 MWth), MB-4 Malé Bielice (Qpv = 3 $l.s^{-1}$, T_{wh} = 39 °C, $Pth_{(INST)}$ = 0.2 MWth), MB-3 Malé Bielice (Qpv = 9 $l.s^{-1}$, T_{wh} = 40 °C, $Pth_{(INST)}$ = 0.9 MWth) and HGTP-1 Partizánske (Qpv = 12 $l.s^{-1}$, T_{wh} = 20 °C, $Pth_{(INST)}$ = 0.3 MWth), all for direct or indirect use in thermal pools. The plan is, however, to connect the HGTP-1 and FGTz-2 Partizánske (Qpv = 12.5 $l.s^{-1}$, T_{wh} = 33 °C, $Pth_{(INST)}$ = 1 MWth) wells to supply heat for a local hybrid district heating system, both, as a low-enthalpy, low-demand source, or as an energy support for heat pumps. Through the monitored period, a real mean monthly thermal output reached 0.3 – 1.3 MWt. Observed peaking is likely due to seasonal demand, however, after a period of increase in 2011 – 2019, there is a general trend of production decline after 2020, due to drop at the Bánovce nad Bebravou site after the COVID pandemics.

4.3 Developable potential

The developable potential – $Pth_{(D)}$ represents part of energy stored in reservoir available for future increase in production at a given operation management, with a respect to sustainable reservoir capacity $Pth_{(S)}$. Although it is a basin-scale indication, at the recent level of geothermal catalog it is enough to consider possibilities to open a production, which (if added to historic withdrawals) – would not exceed a sustainable capacity and would hold the production classification as sustainable, i.e. r_{cap} for $Pth_{(REF*)}$ + $Pth_{(D)}$ > 0.5. At early reservoir development stages, it is recommended to consider both, the $Pth_{(D)}$ > 0 (for cases where $Pth_{(REF*)}$ < $Pth_{(S)}$ and borehole interference tests prior opening the production. The $Pth_{(D)}$ is assumed through:

1) normalizing the thermal output – $Pth_{(REF*)}$ from a production curve as of 2011 – 2024, where cumulative mean monthly output variation gives $Pth_{(REF)}$ = 0.3 – 1.3 MWt implying representative thermal output as high as $Pth_{(REF*)}$ = 1.0 MWt (Fig. 2)

2) harmonizing the $Pth_{(REF*)}$ according to production history statistics then yields $Pth_{(D)}$ = 5 MWt for t_{prod} = 100 years and $Pth_{(D)}$ = 14 MWt for t_{prod} = 40 years.

For that case, projection of $Pth_{(D)}$ + on $Pth_{(REF)}$ through production history assumes r_{cap} = 0.51 – 0.59 for a sustainable, while r_{cap} = 0.51 – 0.54 for short-term production. This is due to a difference between relation of production statistics and representative thermal output to the sustainable reservoir capacity. Obtaining $Pth_{(D)}$ > 0 for both, the short-term and long-term production means the reservoir is capable to cover more energy withdrawal at low risks of rapid response that would pose hazard to both, a reservoir and projects.

The ongoing project for the town of Partizánske schedules 60-days long simultaneous pumping tests for HGTP-1 and FGTz-2 wells, including build-up. A plan is to at least prove recently booked production characteristics, i.e. $Pth_{(INST)}$ = 1.3 MWt as cumulative. The MB-3 in Malé Bielice (app. 2 km away) well will be used for monitoring of borehole interferences or reservoir response during a test. Setting $Pth_{(REF)}$ = $Pth_{(D*)}$ = 1.3 MWt as optimum scenario, and $Pth_{(D*)}$ < $Pth_{(D)}$, the deliverability respective to the planned output must then be proven by no

interference indices during the test. Extended geochemistry monitoring is planned to calibrate reservoir response forecasting models and conceptual hydrogeothermal system models through mixing studies and geothermal water genetic / facial analyzes.

5 CONCLUSIONS

The Bánovská kotlina Basin represents a typical low-enthalpy and conduction-dominated play of the Western Carpathians. Proven geothermal resources are associated with the "shallow reservoir unit" in Mid – Late Triassic carbonates of the Hronicum domain (nappe series) beneath Cenozoic basin fill with a top at z = 0 – 800 m and base at z = 400 – 3200 m. For a steady-state conditions, respective temperatures range T = 18 – 106 °C at a top and T = 25 – 112 °C at its base. Existence of deep reservoir unit is not proven, however, analogy with other intramountain depressions in Slovakia expects at least one reservoir body within Mid Triassic carbonates of the Fatricum domain (nappe series) or Tatricum Cover Unit. A relation to the shallow unit in terms of hydraulic or thermal connectivity is recently unknown.

A basin-scale model of the BKB is constructed according to a stochastic geothermal catalog of resources and reserves constructed for Slovakia. The model combines use of stochastic modeling in recovery factor and booking geothermal reserves conditioned by conceptual models (hydrogeological opening to the surface, vertical structure, hydraulic / thermal connectivity of multiple reservoir units), with reserve capacity ratio to set a sustainable reservoir capacity as benchmark for reservoir production. Adding the cumulative production history with normalized representative thermal output on a reservoir-scale prompts for the developable potential, i.e. amount of thermal energy available for withdrawal, likely avoiding robust changes in reservoir quantities and qualities due to its production response.

According to the stochastic model, the total thermal potential at respective 50 % risk rate counts TTP(p) = 13 MWt for sustainable (t_{prod} = 100 years) and TTP(p) = 31 MWt for short-term (t_{prod} = 40 years) production period. Setting the 50 % of total thermal potential a critical sustainable capacity level corresponding to a reserve capacity ratio r_{cap} = 0.5, the sustainable potential is assumed for $Pth_{(S)}$ = 6 MWt and $Pth_{(S)}$ = 15 MWt respectively. Production history (2011 – 2024 period) curve indicates a cumulative mean monthly thermal output at $Pth_{(REF)}$ = 0.3 – 1.3 MWt if referenced to T_{ref} = 15 °C, i.e. $Pth_{(REF)} < Pth_{(S)}$. Then, normalized thermal output of $Pth_{(REF*)}$ = 1 MWt yields developable potential of $Pth_{(D)}$ = 5 MWt and 13 MWt respectively.

An ongoing project to introduce geothermal resources in the town of Partizánske plans running HGTP-1 and FGTz-2 wells for low-enthalpy, low-energy branch of local district heating system or thermal supply for large heat pumps. The basin-scale stochastic model of developable potential favorizes production development as long as scheduled pumping tests proves recently booked deliverability and thermal output $Pth_{(D*)}$ = 1.3 MWt and forecasting models imply no interference with the nearby Male Bielice site. Combination of all should then secure long term production avoiding risks of reservoir hydraulic and thermal depletion or robust changes in reservoir / resource qualities / quantities if sustainable reservoir management principles will be followed.

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