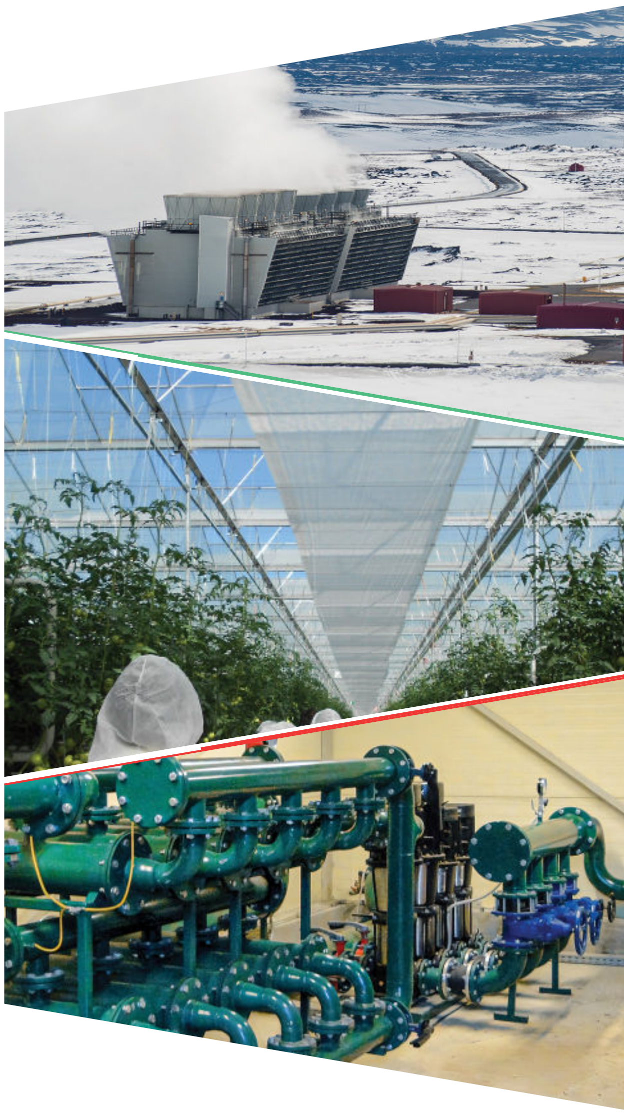
REPUBLIKA SLOVENIJA
MINISTRSTVO ZA KOHEZIJO IN REGIONALNI RAZVOJ

Iceland Liechtenstein Norway grants

INFO-GEOTHERMAL

Podpiranje učinkovite kaskadne uporabe geotermalne energije z dostopom do uradnih in javnih informacij

Supporting efficient cascade use of geothermal energy by unlocking official and public information



Knjižica o energetsko učinkoviti rabi geotermalnih virov in njihovem razvoju

Booklet on energy efficient use of geothermal resources and their development

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GeoZS Geološki zavod Slovenije
REPUBLIKA SLOVENIJA MINISTRSTVO ZA OKOLJE, PODNEBJE IN ENERGIJO
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Knjižica o energetsko učinkoviti rabi geotermalnih virov in njihovem razvoju
Booklet on energy efficient use of geothermal resources and their development

Avtorji/Authors: Nina Rman, Andrej Lapanje, Dušan Rajver, Ines Piščanec, Aleš Jeraj, Gregor Rome
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Projekt INFO-GEOTHERMAL sofinancirajo Islandija, Lihtenštajn in Norveška s sredstvi Finančnega mehanizma EGP v višini 1.073.529,41 €. Namen projekta je podpiranje učinkovite kaskadne uporabe geotermalne energije z dostopom do uradnih in javnih informacij. Več informacij o projektu najdete na https://www.geo-zs.si/index.php/en/?option=com_content&view=article&id=1119, www.eeagrants.org in www.norwaygrants.org.
Vsebina te knjižice je izključna odgovornost projektnih partnerjev in v nobenem primeru ne odraža stališč izvajalca programa za blažitev podnebnih sprememb in prilagajanja nanje.

The project INFO-GEOTHERMAL benefits from a 1,073,529.41 € grant from Iceland, Liechtenstein and Norway through the EEA Grants. The aim of the project INFO-GEOTHERMAL is to support efficient cascade use of geothermal energy by unlocking official and public information. More project information can be found at https://www.geo-zs.si/index.php/en/?option=com_content&view=article&id=1120, www.eeagrants.org and www.norwaygrants.org.
The contents of this booklet are the sole responsibility of project partners and can in no way be taken to reflect the views of the Programme Operator of the Climate Change Mitigation and Adaptation programme.

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Geotermalna energija

Geotermalna energija (GE) je energija, shranjena v obliki toplote pod trdnim zemeljskim površjem in spada med obnovljive vire energije (RED II). GE postaja en izmed ključnih virov za energetsko prestrukturiranje sektorja ogrevanja in hlajenja v Sloveniji. Potenciala za geotermalno električno energijo in pridobivanje mineralnih snovi iz termalne vode v Sloveniji še nista dovolj raziskana.

GE zagotavlja osnovno raven potreb za ogrevanje, hlajenje ali elektriko. Je lokalen vir in poleg razogljičenja prispeva tudi k večji energetski varnosti in raznolikosti. S kaskadno rabo doseže zelo visoko učinkovitost. Podzemno shranjevanje presežkov energije iz drugih OVE močno poveča učinkovitost in stabilizacijo energetskih omrežij. V primerjavi s fosilnimi gorivi ima zelo malo emisij in bolj stabilno ceno energenta.

Plitva GE se izkorišča z geotermalnimi toplotnimi črpalkami in ne potrebuje povišanega geotermičnega gradienta ali termalne vode. Z ustrezno tehnologijo je dostopna skoraj povsod. Po svetu dosega globina takšnih sistemov do 300 - 400 m, prevladujejo pa sistemi plitvejši od 150 m.

Globoka GE se pridobiva s termalno vodo ali pa z umetnim dovajanjem in črpanjem vode skozi segrete kamnine v globinah do 5 km. Termalna voda je pri nas definirana kot podzemna voda, ki na iztoku na površje dosega vsaj 20 ºC. Najlaže dosegljivi in najbolje poznani viri termalne vode so v severovzhodni Sloveniji.

Čeprav je GE obnovljiva, je stopnja obnavljanja lahko počasnejša kot dejanska raba. Zato je trajnostno rabo potrebno načrtovati tako, da je vpliv na vodno in energetsko bilanco minimalen.

Geothermal energy

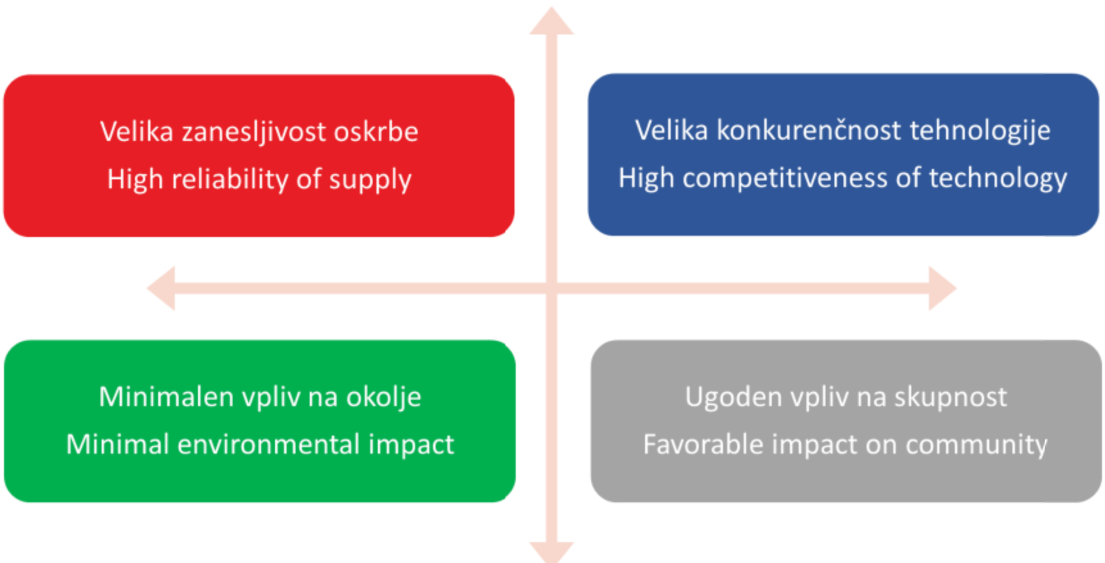
Geothermal energy (GE) is energy stored in the form of heat under the solid Earth's surface, and belongs to renewable energy sources (RED II). GE is becoming one of the key sources for energy restructuring of the heating and cooling sector in Slovenia. The potential for geothermal electricity and the extraction of minerals from thermal water have not yet been sufficiently explored in Slovenia.

GE provides a baseload for heating, cooling or electrical needs. It is a local source and, in addition to decarbonisation, also contributes to greater energy security and diversification. With cascade use, it achieves very high efficiency. Underground storage of excess energy from other RES greatly increases the efficiency and stabilization of energy networks. Compared to fossil fuels, it has very few emissions and a more stable energy price.

Shallow GE is exploited by geothermal heat pumps and does not require an elevated geothermal gradient or thermal water. It is accessible almost everywhere if using proper technology. Around the world, the depth of such systems can be up to 300-400 m, but boreholes shallower than 150 m prevail.

Deep GE is obtained from thermal water or by artificial injection and pumping of water through heated rocks at depths of up to 5 km. In our country, thermal water is defined as groundwater with at least 20 ºC at the outflow. The easiest to reach and best known thermal water resources are found in north-eastern Slovenia.

Although GE is renewable, the recovery rate may be slower than actual use. Therefore, sustainable use must be planned in such a way that the impact on the water and energy balance is minimal.



Projekt INFO-GEOTHERMAL
Project INFO-GEOTHERMAL

Projekt INFO-GEOTHERMAL se je izvajal med septembrom 2022 in aprilom 2024.

Projekt INFO-GEOTHERMAL je prvi projekt, **namenjen inovativni krepitvi zmogljivosti sektorja rabe globoke geotermalne energije v Sloveniji**. Projektni partnerji in njihovi predstavniki so:

- Geološki zavodi Slovenije (vodini partner): doc. dr. Nina Rman
- Ministrstvo za naravne vire in prostor: Aleš Jeraj
- Ministrstvo za okolje, podnebje in energijo: mag. Gregor Rome
- Skupnost občin Slovenije: Jasmina Vidmar
- Islandska šola za energijo: dr. Juliet Ann Newson.

Dosegli smo oba poglavitna cilja: izboljšati razpoložljivosti informacij, ki podpirajo razvoj projektov z učinkovito kaskadno rabo termalne vode, in povečati znanje ter ozaveščenost o trajnostnih načinih rabe globoke geotermalne energije.

Z delavnicami, terenskimi ogledi in strokovnimi srečanji na Islandiji, Hrvaškem in v Sloveniji smo uspeli povezati glavne akterje geotermalnega razvoja v Sloveniji in oblikovati skupne izzive novega nacionalnega geotermalnega združenja.

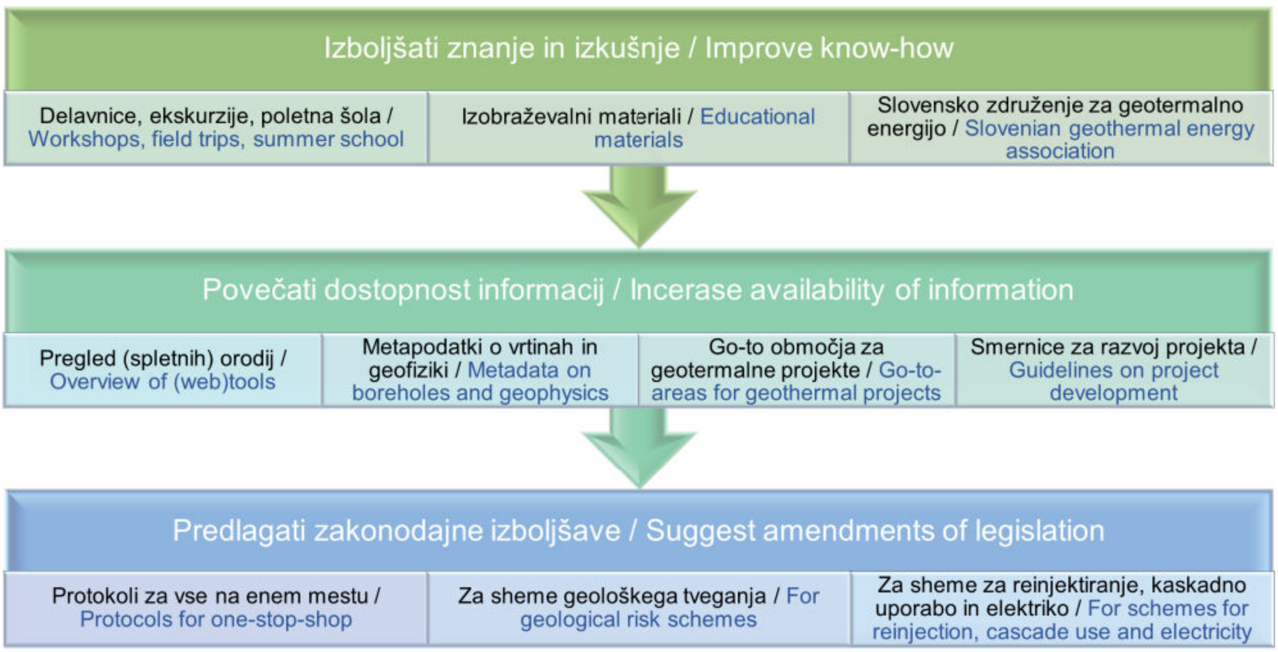
Project INFO-GEOTHERMAL was implemented between September 2022 and April 2024.

The INFO-GEOTHERMAL project is the first project **dedicated to innovative capacity building for the deep geothermal energy sector in Slovenia**. The project partners and their representatives are:

- Geological Survey of Slovenia (lead partner): Assoc. Prof. Dr. Nina Rman
- Ministry of Natural Resources and Spatial Planning: Aleš Jeraj
- Ministry of the Environment, Climate and Energy: mag. Gregor Rome
- Association of Municipalities and Towns of Slovenia: Jasmina Vidmar
- Iceland School of Energy: Dr. Juliet Ann Newson.

We have achieved both of main objectives: to improve the availability of information and support the development of projects with efficient cascade use of thermal water, and to increase knowledge and awareness of sustainable ways to use deep geothermal energy.

Through workshops, field visits and expert workshops in Iceland, Croatia and Slovenia, we have bought together the main players in geothermal development in Slovenia and shaped the common challenges of the new national geothermal association.



78 strokovnjakov na delavnicah za uporabo smernic
experts at workshops for the use of guidelines

24 študentov iz 15 držav na poletni geotermalni šoli
students from 15 countries at the geothermal summer school

27 strokovnjakov in lokalnih skupnosti na usposabljanju na Islandiji
experts and local authorities at training in Iceland

5 islandskih strokovnjakov na poletni šoli in delavnicah v Sloveniji
Icelandic experts at the summer school and workshop in Slovenia

95 predstavnikov lokalnih skupnosti na dogodkih
representatives of local authorities at events

59 predstavnikov podjetij ter podpornih organizacij na dogodkih
representatives of companies and supporting organizations at events

8 predstavnikov sektorskih agencij na delavnicah in terenskih ogledih
representatives of sector agencies at workshops and field trips

30 strokovnjakov iz Evrope in ZDA na okrogli mizi
experts from Europe and the USA at a round table

7 osnovnih šol in več kot 500 učencev na geoloških delavnicah
primary schools and more than 500 pupils at geological workshops

12 predstavnikov nacionalnih upravnih organov na delavnicah in terenskih ogledih
representatives of national authorities at workshops and field visits

73 predstavnikov fakultet in raziskovalnih organizacij na poletni šoli in delavnicah
representatives of faculties and research organizations at the summer school and workshops

Seznam rezultatov projekta INFO-GEOTHERMAL

DT 1. 1. 1.	Analiza tipičnih vprašanj in odgovorov občin in potencialnih vlagateljev
DT 1. 1. 2.	Poročilo o pregledu (spletnih) orodij in vrst informacij javnega značaja v sosednjih državah in na Islandiji
DT 1. 1. 3.	Delavnica in ogled študijskih primerov na Islandiji
DT 1. 2. 1.	Poročilo o oceni razpoložljivih podatkov in predlog raziskav
DT 1. 2. 1.	Metapodatki globokih vrtin in seizmičnih profilov
DT 1. 2. 2.	Pregledovalnik 3D geotermalnega modela SV Slovenije
DT 1. 2. 2.	Poročilo o 3D digitalnem geotermalnem modelu SV Slovenije
DT 1. 2. 3.	Prednostna območja za geotermalne objekte - občina Beltinci
DT 1. 2. 3.	Prednostna območja za geotermalne objekte - občina Turnišče
DT 1. 2. 3.	Prednostna območja za geotermalne objekte - občina Dobrovnik
DT 2. 1. 1.	Poročilo o zakonodajnih postopkih s predlogi izboljšav
DT 2. 1. 2.	Poročilo o prilagoditvi zakonodaje za geološka tveganja
DT 2. 1. 3.	Poročilo o prilagoditvi zakonodaje za elektriko
DT 2. 2. 1.	Poročilo o vzpostavitvi enotne vstopne točke
DT 2. 2. 3.	Finančni mehanizmi za geotermalne projekte
DT 3. 1. 1.	Smernice za razvoj geotermalnih vrtin
DT 3. 1. 2.	Smernice za zmanjšanje tveganja reinjekcijskih vrtin
DT 3. 1. 4.	Smernice za razvoj projektov direktne rabe
DT 3. 1. 4.	Smernice za razvoj projektov - ENERGETIKA
DT 3. 1. 5.	Smernice za razvoj geotermalne elektrarne
DT 4. 1. 1.	Poletna geotermalna šola - knjiga povzetkov
DT 4. 2. 1.	Kodeks ravnanja. Del 1 - Pregled stanja
DC 3. 1.	Predstavitev zaključkov projekta INFO-GEOTHERMAL
DC 3. 1.	Izjava za medije ob zaključku projekta INFO-GEOTHERMAL
DC 6. 1	Informacijske table o učinkoviti in kaskadni uporabi geotermalne energije
DC 6. 2.	Fizični model geotermalnih rezervoarjev v SV Sloveniji

Results of project INFO-GEOTHERMAL

DT 1. 1. 1.	Q & A report in geothermics
DT 1. 1. 2.	Report on overview of (web)tools and types of public information in the neighbouring cou-ntries and Iceland
DT 1. 1. 3.	Workshop and study cases on Iceland
DT 1. 2. 1.	Report on available data and new research
DT 1. 2. 1.	Metadata of deep boreholes and seismic lines
DT 1. 2. 2.	Viewer of 3D geothermal model of NE Slovenia
DT 1. 2. 2.	Report on 3D digital geothermal model of NE Slovenia
DT 1. 2. 3.	Go to areas for geothermal projects - Municipality Beltinci
DT 1. 2. 3.	Go to areas for geothermal projects - Municipality Turnišče
DT 1. 2. 3.	Go to areas for geothermal projects - Municipality Dobrovnik
DT 2. 1. 1.	Report on legislation and suggestions for improvements
DT 2. 1. 2.	Report on legislation adaptation for geological risk
DT 2. 1. 3.	Report on legislation adaptation for electricity
DT 2. 2. 1.	Report on establishment of web one stop shop
DT 2. 2. 3.	Funding mechanisms for geothermal projects
DT 3. 1. 1.	Guidelines on the development of projects of geothermal wells
DT 3. 1. 2.	Guidelines on geothermal reinjection wells
DT 3. 1. 4.	Guidelines to develop direct use
DT 3. 1. 4.	Guidelines to develop direct use - ENERGY
DT 3. 1. 5.	Guidelines to develop geothermal power plant
DT 4. 1. 1.	Geothermal summer school - abstract book
DT 4. 2. 1.	Code of conduct. Part 1 - Overview
DC 3. 1.	INFO-GEOTHERMAL presentation of final project results
DC 3. 1.	INFO-GEOTHERMAL media statement at the end of the project
DC 6. 1	Info boards on efficient and cascade use of geothermal energy
DC 6. 2.	Physical model of geothermal reservoirs in NE Slovenia

Izzivi geotermalnega sektorja

Challenges of the geothermal sector

Projekt INFO-GEOTHERMAL je nagovarjal glavne izzive razvoja geotermalnega sektorja v Sloveniji, ki so zelo podobni širši evropski sliki. Mednarodna iniciativa GEOTHERMICA izpostavlja ključne izzive:

- dialog po celotni verigi deležnikov,
- dostop do kakovostnih podatkov o podpovršju,
- geološko tveganje naj s pilotnimi raziskavami odpravi država,
- zmanjševanje administrativnih ovir pri podeljevanju dovoljenj,
- vzpostavljen sistem za upravljanje s tveganji in finančnimi podpornimi shemami,
- krepitev kapacitet z usposabljanjem strokovnjakov in tehnološkim razvojem in
- doseganje družbene sprejemljivosti projektov s transparentnostjo informacij, da se uči tudi iz napak.

Tudi **Resolucija Evropskega parlamenta o geotermalni energiji** iz 18. januarja 2024 (2023/2111(INI)) poudarja potrebo po sistematični podpori geotermalnem sektorju, ki naj zajema:oblikovanje skupne evropske in nacionalnih geotermalnih strategij za plitve, srednje, globoke in ultra-globoke geotermalne vire:

- zbiranje in javno objavo digitalnih geoloških podatkov in statistik rabe,
- kartiranje naravnega potenciala geotermalnih virov in dejanskih energetskih potreb,
- nadgradnjo daljinskih sistemov ogrevanja in hlajenja v nižje temperaturne - 4. in 5. generacijo,
- načrtno usposabljanje inštalaterjev in projektantov ter drugih strokovnjakov v sektorju,
- spodbujanje mednarodnega sodelovanja za povečanje znanja in prenosa tehnologij ter doseganje družbene sprejemljivosti projektov,
- vzpostavitev digitalne enotne vstopne točne za pridobitev dovoljenj,
- uskladitev finančnih shem za zavarovanje tveganj,
- vzpostavitev geotermalne industrijske zveze za hitrejši prenos dobrih praks in
- podporo premogovnim regijam in regijam v prehodu pri preusmeritvi v geotermalne regije.

Ob tem je pomembno, da razvoj sektorja geotermalne energije hkrati podpirajo številne druge evropske usmeritve, med drugim REPowerEU, Pripravljeni na 55, Direktivi o spodbujanju uporabe energije iz obnovljivih virov ter o energetski učinkovitosti in Akt o neto ničelni industriji.

The INFO-GEOTHERMAL project addressed the main challenges for the development of geothermal sector in Slovenia, which are very similar to the broader European picture. The international GEOTHERMICA initiative highlights key challenges such as:

- dialogue across the whole stakeholder chain,
- access to quality subsurface data,
- geological risk to be addressed by the State through pilot studies,
- reduction of administrative barriers to licensing,
- establishment of risk management and financial support schemes,
- capacity building through training of experts and technological development; and
- achievement of social acceptance of projects through transparency of information in order to learn from mistakes.

The European Parliament resolution of 18th January 2024 on geothermal energy (2023/2111(INI)) stresses the need for systematic support for the geothermal sector, which should include:

- the development of common European and national geothermal strategies for shallow, medium, deep and ultra-deep geothermal resources,
- the collection and open publication of digital geological data and usage statistics,
- the mapping of natural geothermal potential and actual energy needs,
- the upgrade of district heating and cooling systems to lower temperature - 4th and 5th generation,
- the training of installers and designers and other professionals in the sector,
- the promotion of international cooperation to increase knowledge and technology transfer and achieve social acceptance of projects,
- the establishment of a digital single-entry point for permits,
- the harmonisation of financial risk insurance schemes,
- the establishment of a geothermal industry alliance to accelerate the transfer of good practices,
- the support for coal regions and regions in transition in their conversion to geothermal.

Importantly, the development of the geothermal energy sector is supported by a number of other European policies, including REPowerEU, Fit for 55, the Directives on the Promotion of the Use of Energy from Renewable Sources and on Energy Efficiency, and the Net Zero Industry Act.i.

Strateške usmeritve

Pariški podnebni sporazum in Evropski zeleni dogovor se nadgrajujeta z evropsko strateško vizijo Čist planet za vse, Energetsko-podnebnim paketom **Pripravljeni za 55** in novim poglavjem Načrta za okrevanje in odpornost **RePowerEU**, ki usmerjajo skupno podnebno in energetsko politiko. Strateški ukrepi se, med drugim, nanašajo na povečanje energijske učinkovitosti stavb, povečanje rabe obnovljivih virov energije (OVE) z elektrifikacijo in decentralizacijo proizvodnje, diverzifikacijo energetskih virov ter shranjevanjem energije v velikem obsegu, razvojem infrastrukture pametnih omrežij in zajemanjem ter shranjevanjem ogljika.

Strategija EU za ogrevanje in hlajenje do 2050 preučuje možnosti razogljičenja, vključno v industriji in stavbah, ki so glavni porabniki ogrevanja in hlajenja. Ključni gradniki scenarijev ogrevanja in hlajenja so energetska učinkovitost, uporaba obnovljivih virov energije (tudi geotermalne energije), hibridni sistemi ogrevanja, povezovanje sektorjev, krožno gospodarstvo ter zajemanje in shranjevanje ogljika za spopadanje s preostalimi emisijami v industriji. Izpostavlja tudi potrebno po objektih za dnevno in sezonsko skladiščenje toplote, kjer je slednje v domeni geotermalnega sektorja.

Strategija EU za povezovanje energetskega sistema in **Evropska strategija za vodik** posegata na področje geotermalnih virov s poudarkom zagotavljanja nizkoogljičnih, zanesljivih in gospodarnih virov s soproizvodnjo toplote in električne energije in razvojem pametnih sistemov daljinskega ogrevanja in hlajenja.

Usmeritve so prenesene v **Strategijo razvoja Slovenije 2030** in druge strateške dokumente. Slovenija zasleduje prehod v nizkoogljično krožno gospodarstvo in trajnostno upravljanje naravnih virov, ob tem pa je »zanesljiva, trajnostna in konkurenčna oskrba z energijo ključna za razvoj, pri čemer je dajanje prednosti učinkoviti rabi (URE) in OVE eno od temeljnih načel energetike«.

Strategic directions

The Paris Climate Agreement and the European Green Deal build on Europe's strategic vision A Clean Planet for All, **Fit for 55** Energy and Climate Package and the new chapter of the **RePowerEU** Recovery and Resilience Plan, which guide common climate and energy policy. The strategic actions relate, inter alia, to increase the energy efficiency of buildings, the use of renewable energy sources (RES) through electrification and decentralisation, diversification of energy sources and large-scale energy storage, development of smart grid infrastructure, and carbon capture and storage.

The EU Heating and Cooling Strategy 2050 explores decarbonisation options, including in industry and buildings, which are the main consumers of heating and cooling. Key building blocks of the heating and cooling scenarios are energy efficiency, use of RES (including geothermal), hybrid heating systems, sector integration, circular economy and carbon capture and storage to tackle residual emissions in industry. It also highlights the need for daily and seasonal heat storage facilities, where the latter is the domain of the geothermal sector.

The EU Strategy on Energy System Integration and **the European Hydrogen Strategy** intersect with the field of geothermal resources with a focus on providing low-carbon, reliable and cost-effective sources through combined heat and power, and the development of smart district heating and cooling systems.

The guidelines are implemented in the **Slovenian Development Strategy 2030** and other strategic documents. Slovenia is pursuing the transition to a low-carbon circular economy and the sustainable management of natural resources, while "a reliable, sustainable and competitive energy supply is key to development, with the prioritisation of efficient use and RES as one of the fundamental principles of the energy sector".

Nacionalni energetski in podnebni načrt Republike Slovenije predvideva več aktivnosti za spodbujanje večnamenske rabe globoke geotermalne energije. Razvrstimo jih lahko v štiri kategorije. Okoljsko usmerjene ciljajo na pospešitev raziskav in pripravo strokovnih podlag za oceno okoljsko sprejemljivega obsega izkoriščanja termalne vode, pripravo projektih pogojev glede sprejemljivih vplivov na okolje in vzpostavitev monitoringa globokih geotermalnih vodonosnikov. Razvojne aktivnosti zajemajo izdelavo interaktivnih kart potenciala globoke geotermalne energije za različne namene rabe z opredelitvijo prioritetnih območij za raziskovanje in investicijske spodbude, vpeljavo kriterijev za spodbude in letno sledenje trendov učinkovitosti rabe glede na tehnični potencial. Investicijske spodbude zajemajo izgradnjo novih proizvodnih in reinjekcijskih vrtin s ciljem čim večjega vračanja toplotno izrabljene termalne vode nazaj v vodonosnik, rabo najnaprednejših tehnologij za učinkovito kaskadno rabo, rabo termalne vode v sistemih daljinskega ogrevanja (vključno z uporabo (velikih) toplotnih črpalk) ter za potrebe kmetijstva in pilotni projekt za proizvodnjo geotermalne električne energije bodisi s preureditvijo obstoječih neaktivnih ali z novimi raziskovalnimi vrtinami. Upravne aktivnosti predvidevajo kontinuirano delovanje medresorske delovne skupine in sodelovanje pri upravljanju s termalno vodo s sosednjimi državami.

Slovenska strategija pametne specializacije do 2030 (S5) izpostavlja trajnostni vidik, zeleni prehod in trajnostno modro gospodarstvo. Med prednostnimi področji so energetska izraba odpadnih snovnih tokov (t.i. waste to energy), oskrba iz OVE (tudi geotermalni viri), sistemi za optimiranje energetske in snovne učinkovitosti (raba odpadne toplote, optimizacija prenosa toplote v industrijskih procesih), pametne skoraj nič-energijske stavbe, avtomatizacija distribucijskega omrežja, celostno upravljanje energije in podobno.

The National Energy and Climate Plan of Slovenia foresees several activities to encourage and support the multifunctional utilization of deep geothermal energy. They can be classified into four categories. The environmentally oriented ones aim at speeding up research and expert grounds for assessing the environmentally acceptable extraction of thermal water, preparing project conditions regarding acceptable environmental impacts and setting up monitoring of deep geothermal aquifers. Development activities include the production of interactive maps of the potential of deep geothermal energy for different uses with the identification of go-to-areas for investment incentives, the introduction of criteria for incentives and the annual evaluation of trends in the efficiency of use in relation to the technical potential. Investment incentives are several. The construction of new production and reinjection wells with the aim of maximising reinjection of thermal water is one, the use of best available technologies for cascade use the second, the use of thermal water in district heating systems (including the use of (large) heat pumps) and for agriculture the third. Also, pilot project for the production of geothermal electricity, either through retrofitting inactive wells or through new exploratory wells, is included. Administrative activities foresee the continued operation of the inter-ministerial working group and cooperation with neighbouring countries on thermal water management.

The Slovenian Smart Specialisation Strategy 2030 (S5) highlights sustainability, the green transition and a sustainable blue economy. Relevant priority themes include the energy recovery of waste material flows (waste to energy), supply from RES (including geothermal sources), systems for optimising energy and material efficiency (waste heat recovery, optimisation of heat transfer in industrial processes), smart near-zero-energy buildings, distribution network automation, and integrated energy management.

Strategija prostorskega razvoja Slovenije 2050 vzpodbuja prednostno rabo OVE, tudi geotermalne energije ter toplote okolja. Kot prednostni območji za soproizvodnjo toplote in električne energije v bližini večjih naselij in gospodarskih con navaja severovzhodno Slovenijo – med Šentiljem in Šalovci, med Ptujem in Lendavo ter pri Benediktu v Slovenskih goricah. Območja ob sistemih rabe geotermalne energije so tudi območja za opredelitev prednostnih območij kaskadne rabe energije, vključno za kmetijske namene, ob upoštevanju drugih prostorskih omejitev. Podaja, da se za rabo geotermalnih virov določijo tehnični pogoji za preprečitev trajnih vplivov na hidrološke razmere vodonosnikov (na primer, način reinjektiranja termalne vode in druge tehnike za zmanjšanje pritiskov na obstoječe stanje vodnega okolja).

Dolgoročna podnebna strategija do leta 2050 postavlja cilj podnebne nevtralnosti oz. ničelne stopnje neto emisij toplogrednih plinov. Ker se geotermalna energija uvršča med še ne dovolj izkoriščene potenciale OVE, Slovenija spodbuja njeno izkoriščanje. Prednostna področja in usmeritve rabe geotermalne energije določa Strategija ogrevanja in hlajenja z akcijskim načrtom. Pomen daje, med drugim, proizvodnji nizkotemperaturne toplote ter trajnostnem in učinkovitem koriščenju toplote termalne vode in plitve geotermalne energije. Na območjih zgoščenih poselitev je daljinsko ogrevanje prednostni način ogrevanja stavb, zunaj teh območij pa je način ogrevanja usmerjen predvsem v toplotne črpalke. Omenja pomen gradnje hranilnikov toplote v vseh sektorjih in potrebo po celovitem lokalnem načrtovanju, podprtem z ustreznimi orodji in podatki. Podnebna strategija določa, da je pomemben tudi način koriščenja geotermalne energije v povezavi s področjem upravljanja voda.

Načrt upravljanja voda na vodnem območju Donave za obdobje 2022–2027 v zvezi z izkoriščanjem geotermalne energije predvideva doseganje okoljskih ciljev za vodna telesa podzemnih voda. Z vidika koriščenja toplote termalne vode iz geotermalnih vodonosnikov in plitve geotermalne energije je treba zagotovi doseganje okoljskega cilja preprečitve ali omejitve vnašanja onesnaževal v podzemno vodo in okoljskega cilja varovanja, izboljšanja in obnavljanja vodnih teles podzemne vode ter zagotoviti ravnotežje med odvzemanjem in obnavljanjem podzemne vode tako, da se doseže njeno dobro kemijsko in količinsko stanje v skladu s predpisi, ki urejajo varstvo okolja.

The Spatial Development Strategy 2050 encourages the priority use of RES, including geothermal energy and ambient heat. It identifies north-eastern Slovenia - between Šentilj and Šalovci, between Ptuj and Lendava, and near Benedikt in Slovenske gorice - as priority areas for cogeneration of heat and electricity in the vicinity of major settlements and economic zones. Areas adjacent to geothermal energy systems are also identified as a priority for cascade use, including for agricultural purposes, taking into account other spatial constraints. The use of geothermal resources is specified to be subject to technical conditions to avoid permanent impacts on the hydrological status of aquifers (for example, the reinjection of thermal water and other techniques to reduce pressures on the existing state of the aquatic environment).

The Long-term Climate Strategy sets a target of climate neutrality or zero net greenhouse gas emissions by 2050. As geothermal energy is one of the most under-used RES potentials, Slovenia is promoting its utilization. The priority areas and orientations for the use of geothermal energy are set out in the Heating and Cooling Strategy Action Plan. Among others, it gives importance to the production of low-temperature heat and the sustainable and efficient use of thermal water and shallow geothermal energy. In areas of concentrated settlement, district heating is the preferred method of heating buildings, while outside these areas the heating is mainly heat pump-oriented. It mentions the importance of building heat storage in all sectors and the need for comprehensive local planning, supported by appropriate tools and data. The Climate Strategy also identifies the importance of how geothermal energy can be used in conjunction with water management.

The Danube River Basin Management Plan 2022-2027 foresees the achievement of environmental targets for groundwater bodies in relation to the exploitation of geothermal energy. With regard to the use of thermal water from geothermal aquifers and shallow geothermal energy, it is necessary to ensure that the environmental objective of preventing or limiting the introduction of pollutants into groundwater and the environmental objective of protecting, improving and recharging groundwater bodies are met. There needs to be a balance between extraction and recharge of groundwater to achieve a good qualitative and quantitative status of groundwater bodies in accordance with the rules governing environmental protection.

Predlogi prilagoditve zakonodaje

Trenutno področje geotermalne energije pokrivajo trije zakoni: **Zakon o vodah, Zakon o rudarstvu in Zakon o uvajanju naprav za proizvodnjo električne energije iz obnovljivih virov energije**. Slednji pokriva le proizvodnjo električne energije, pri čemer novih geotermalnih raziskav za te namene še ni.

Pri prilagoditvah je potrebno upoštevati ustavno načelo enake obravnave vseh subjektov in že na ravni zakonov jasno razmejiti njihove pristojnosti. Podali smo nekaj predlogov.

- Ker področje urejajo kar trije zakoni, ki se vsebinsko dokaj prekrivajo, je smiselno opustiti ureditev vsaj v enem od njih.
- Zakon o vodah naj pokriva vse primere premeščanja termalne podzemne vode, nepovratne odvzeme in tudi če je zagotovljena popolna reinjekcija.
- Zakon o vodah in Zakon o uvajanju naprav za proizvodnjo električne energije iz obnovljivih virov energije bi se lahko vsebinsko dopolnila, da bi spodbujala boljšo raziskanost globokega podzemlja in podelitev raziskovalnih geotermalnih koncesij kot na Madžarskem in Hrvaškem. Podobno je urejeno raziskovanje ogljikovodikov.
- Definicije v predpisih naj bodo fizikalno ustrezne, saj sicer prihaja do administrativnih zapletov in nelogičnosti.
- Z medresorskim sodelovanjem je potrebno povezati predpise in zahteve v zvezi z izvajanjem vodne direktive v primeru obstoječih rudarskih koncesij za rabo geotermičnega energetskega vira (opazovanje stanja, nadzor rabe in poročanje).
- Smiselno je poenotiti okoljske dajatve preko podobnih pogojev in načina izračuna višine plačila (ali olajšav) za koncesije. Formula za plačilo za koncesijo v primeru reinjekcije po Zakonu o vodah naj se približa formuli po Zakonu o rudarstvu.
- Presoditi je potrebno, ali je vodno povračilo za črpanje termalne vode brez reinjekcije, tam, kjer je vračanje mogoče, ustrezen mehanizem za spodbujanje trajnostne rabe.
- Država naj zagotovi centralno zbiranje arhivskih in novih podatkov v okviru javne rudarske službe ali sorodnega organa, podatke skrbno hrani, ureja in interpretira ter daje na vpogled zainteresirani javnosti pod točno določenimi pogoji.
- Ob subvencioniranju večjih projektov rabe se v razpisno dokumentacijo doda pogoj o zagotavljanju javnosti podatkov, pridobljenih med izgradnjo in delovanjem sistemov rabe, npr. o zgradbi podpovršja, rezultatih testiranja, monitoringu stanja in učinkovitosti delovanja sistemov.
- Vzpostaviti je potrebno sistem izvajanja nacionalnih globokih geoloških raziskav po vnaprej določenih prioritetah in načrtu dela za 5 ali 10 let.
- Slovenija naj po vzoru nekaterih sosednjih držav od Evropske komisije zahteva spremembo pristopa k financiranju razvojnih in kohezijskih projektov. Kazalniki uspešnega kohezijskega projekta naj postanejo, na primer, večja raziskanost neke površine državnega ozemlja v izbrani globini in izvedba globokih raziskovalnih vrtin in ne, kot sedaj, inštalirana kapaciteta naprave. Razločevanje financiranja glede na tehnologije mora postati dovoljeno, da bomo lahko izkoristili svoje naravne danosti ter ohranili rudarsko industrijo.
- Spremeniti je potrebno kazalnike oziroma cilje javnih investicijskih razpisov ali predpisanih cen za podpore - iz inštaliranih moči (MW) na količino pridobljene energije (GWh). Sistemi za rabo geotermalne energije so edini OVE, ki zaradi stalnega delovanja kljub razmeroma nizki inštalirani moči pridobijo večjo ali primerljivo količino energije kot drugi OVE.
- Shemo državnih pomoči je potrebno dopolniti tako, da bo mogoče podpreti naložbe kaskadne rabe geotermalne energije v energetiki, gospodarstvu in kmetijstvu hkrati. Trenutna shema državnih pomoči na področju OVE ne dovoljuje dodeljevanje pomoči primarni kmetijski proizvodnji.
- Upravljanje kmetijskih zemljišč je treba prilagoditi, morda z oblikovanjem regionalnih prostorskih načrtov, da bi omogočili spremembe, ki dovoljujejo postavitev trajnih industrijskih rastlinjakov.
- Dolgoročna cenovna politika mora biti transparentna in predvidljiva.

Proposals for legislative adjustments

Currently, the field of geothermal energy is governed by three laws: **the Water Act, the Mining Act, and the Act on the Siting of Installations for Generation of Electricity from Renewable Energy Sources**. The latter only addresses electricity generation, while no new geothermal explorations for these purposes have been initiated.

In adjusting legislation, it is essential to consider the constitutional principle of equal treatment of all entities and to clearly delineate their responsibilities at the legislative level. We have made several proposals.

- Given that the field is regulated by three laws, which significantly overlap, it would be reasonable to eliminate regulation under at least one of them.
- The Water Act should cover all cases of moving the thermal water, including irreversible withdrawals, and even when full reinjection is ensured.
- The Water Act and the Act on the Siting of Installations for Generation of Electricity from Renewable Energy Sources could be amended to promote better exploration of deep underground and for granting the exploration geothermal concessions, like the practices in Hungary and Croatia. This approach is comparable to the regulation on hydrocarbon exploration.
- Definitions in the regulations should be physically accurate, as administrative complications and inconsistencies arise otherwise.
- Inter-ministerial cooperation is needed to harmonize regulations and requirements related to the implementation of the Water Directive, particularly concerning existing mining concessions for the use of geothermal energy sources (monitoring conditions, control of production, and reporting).
- It is reasonable to standardize environmental levies by aligning conditions and methods for calculating payments (or exemptions) for concessions. The formula for concession fees under the Water Act when water is reinjected should be aligned with the formula used in the Mining Act.
- There should be an assessment of whether the water fee for extracting thermal water without reinjection, where reinjection is feasible, is an appropriate mechanism for encouraging sustainable use.
- The state should ensure the central collection of archive and new data within the framework of the public mining service or a related authority. This data should be carefully stored, organized, interpreted, and made available to the interested public under clearly defined conditions.
- When subsidizing larger utilization projects, a condition should be added to the tender documentation, requiring the disclosure of data obtained during the construction and operation of the systems, such as geological structure, testing results, operational monitoring, and system performance.
- A system for conducting national deep geological surveys must be established, based on predetermined priorities and a 5- or 10-year work plan.
- Slovenia should, following the example of some neighbouring countries, request the European Commission to change its approach to funding development and cohesion projects. Indicators of a successful cohesion project should include, for example, increased exploration of a certain area of national territory at a specified depth and the completion of deep research boreholes, rather than the current focus on installed capacity. Differentiating funding by technology should be allowed to leverage our natural resources and maintain our mining industry.
- Public investment tender indicators or support pricing mechanisms should be revised, shifting the focus from installed capacity (MW) to the amount of energy produced (GWh). Geothermal energy systems are the only RES that, due to continuous operation, can generate more or comparable energy to other RES despite relatively low installed capacity.
- The state aid scheme needs to be amended to enable support for investments in cascading use of geothermal energy across the energy, industrial, and agricultural sectors simultaneously. The current state aid scheme for RES does not permit aid for primary agricultural production.
- The management of agricultural land must be adapted, potentially through the development of regional spatial plans, to allow for changes that permit construction of permanent industrial greenhouses.
- Long-term pricing policy must be transparent and predictable.

Finančni mehanizmi

Finančni viri za razvoj geotermalnega sektorja so na voljo. Vendar pozicioniranje geotermalnega sektorja znotraj energetike in črpanje sredstev nista zadovoljiva.

Za uspešnejše pridobivanje sredstev je potrebno izboljšati poznavanje finančnih mehanizmov, pravočasno pripraviti dokumentacijo in projekte uvrstiti v strateške dokumente. Hitrejši razvoj bo omogočilo tudi oblikovanje enotne vstopne točke OVE, nadgrajen dostop do javnih podatkov o podpovršju, izboljšano znanje vseh deležnikov in pilotna izvedba novih inovativnih in pogumnih, a izvedljivih razvojnih idej.

Možni finančni mehanizmi so:
- Obzorje Evropa
- Sklad za inovacije
- Sklad za modernizacijo
- Program LIFE – podprogram Prehod na čiste energije LIFE 2021–2027
- Instrument za povezovanje Evrope (CEF Energy)
- Evropska investicijska banka (EIB)
- Sklad za pravični prehod
- Sklad za odpornost in okrevanje
- Evropski sklad za regionalni razvoj (INTERREG programi)
- Financiranje zasebnega sektorja na ravni EU
- Sklad za podnebne spremembe
- EKO sklad
- Norveški finančni mehanizem in Finančni mehanizem Evropskega gospodarskega prostora (EGP)
- Švicarski nacionalni prispevek
- Strateška razvojna in inovacijska partnerstva (SRIP)
- Javna agencija za znanstvenoraziskovalno in inovacijsko dejavnost (ARIS)

Funding mechanisms

Financial resources for the development of the geothermal sector are available. However, the positioning of the sector within the energy field and the mobilization of funds are not satisfactory.

To improve the acquisition of funds, it is necessary to enhance the understanding of financial mechanisms, prepare documentation in a timely manner, and integrate projects into strategic documents. Faster development can also be achieved through the establishment of a one-stop-shop for renewable energy, improved access to public subsurface data, enhanced knowledge among all stakeholders, and the pilot implementation of new, innovative, and bold yet feasible development ideas.

Possible financial mechanisms include:
- Horizon Europe
- Innovation Fund
- Modernisation Fund
- LIFE Programme – Subprogramme for Clean Energy Transition LIFE 2021–2027
- Connecting Europe Facility (CEF Energy)
- European Investment Bank (EIB)
- Just Transition Fund
- Recovery and Resilience Facility
- European Regional Development Fund (ERDF) (INTERREG programmes)
- EU-Level Private Sector Financing
- Climate Action Fund
- Eco Fund
- Norwegian Financial Mechanism and European Economic Area (EEA) Financial Mechanism
- Swiss National Contribution
- Strategic Research and Innovation Partnerships (SRIPs)
- Slovenian Research and Innovation Agency (ARIS)

Vzpostavitev enotne vstopne točke
Establishment of a One-Stop-Shop

Podatki, pridobljeni z vrtanjem in drugimi globokimi raziskavami, so ključni za področja, kot so mineralne surovine, geotermalna energija in podzemna voda. Zato je nujno, da se zbirajo skupaj in omogočajo učinkovito gospodarjenje z različnimi viri. Ker podelitev koncesije za rabo enega vira lahko izključi ali omeji uporabo drugega, je potrebno usklajevati njihov razvoj med različnimi sektorji in v skladu z interesi skupnosti. K temu lahko prispeva vzpostavitev enotne vstopne točke.

V skladu s 51. členom Zakona o spodbujanju rabe obnovljivih virov energije je Slovenija že ustanovila kontaktno točko za spodbujanje obnovljivih virov energije, ki je dostopna na naslovu: https://borzen.si/sl-si/tocka-ove. Točka vlagatelje vodi skozi administrativne postopke za uporabo tehnologij za ogrevanje in proizvodnjo elektrike ter lahko pomaga pri celotnem upravnem postopku.

Vzpostavitev spletne enotne vstopne točke za globoko geotermijo ni enostavna ali kratkoročna naloga. Pripravili smo smernice in predlog specifikacij za postavitev centraliziranega informacijskega sistema geotermalne energije (IS GE). S tem bo omogočeno:

- spodbujati rabo na območjih z največjim potencialom,
- podpirati učinkovito kaskadno rabo,
- zmanjšati tveganja razvoja novih projektov in
- pripraviti ocene drugih globokih potencialov, npr. podzemnega skladiščenja energije in plinov.

Za izvedbo IS GE je potrebnih nekaj korakov:

- ureditev zakonodaje, ki omogoča organizacijo in dostop do podatkov,
- ureditev lastništva in objavljivosti podatkov,
- postavitev zasnove enotnega informacijskega sistema,
- zbiranje in priprava obstoječih arhivov za digitalizacijo,
- digitalizacija podatkov, preverba kakaovosti,
- organizacija podatkov v informacijskem sistemu in
- priprava storitev za dostop do teh podatkov.

Data obtained from drilling and other deep exploration activities are essential also for mineral resources, geothermal energy, and groundwater. Therefore, it should be collected jointly to enable effective management of various resources. Since the granting of a concession for the use of one resource can exclude or limit the exploitation of another, it is necessary to coordinate their development across different sectors in line with community interests. The establishment of a one-stop-shop could contribute to this coordination.

In accordance with Article 51 of the Act on the Promotion of the Use of Renewable Energy Sources, Slovenia has already established a contact point for promoting renewable energy: https://borzen.si/sl-si/tocka-ove. It guides applicants through the administrative procedures for the use of heating and electricity generation and can assist throughout the entire administrative process.

The establishment of a one-stop-shop for deep geothermal energy is neither a simple nor a short-term task. We have prepared guidelines and proposed specifications for the elaboration of a centralized information system on geothermal energy (IS GE). This system will enable:

- Promoting utilization in areas with the highest potential,
- Supporting efficient cascade use,
- Reducing risks associated with the development of new projects, and
- Assessing other deep potentials, such as for underground energy and gas storage.

Several steps are required for successful implementation of IS GE:

- Adjustment of legislation to allow for the organization and access to data,
- Resolution of data ownership and publication rights,
- Design of a unified information system,
- Collection and preparation of existing archives for digitization,
- Data digitization and quality verification,
- Organization of data within the information system, and
- Preparation of services to provide access to this data.

Predlog nacionalnih raziskav

Proposal for national survey

Območja slovenskih mest so le redko raziskana globlje od (nekaj) sto metrov, do koder segajo viri pitne podzemne vode in viri plitve geotermalne energije. Raziskave globoke geološke zgradbe so potekale predvsem za iskanje nahajališč ogljikovodikov in podzemnih skladišč zemeljskega plina. Geotermalni vodonosniki v SV Sloveniji se sicer nahajajo na istem območju, vendar bodisi plitveje (termalna voda za direktno rabo toplote) bodisi globlje (geotermalni fluidi za proizvodnjo električne energije) od že raziskanih plasti.

Zato predlagamo sistematične globoke raziskave z globinskim dosegom 2 do 5 km, ki bodo odgovorile na aktualne energetske izzive: a) ali je pod večjimi mesti, ki morajo menjati vire ogrevanja daljinskih sistemov, primeren geotermalni vodonosnik, b) kje imamo primerne vire za proizvodnjo geotermalne elektrike, ter c) kje je najbolj ekonomično uporabljati termalno vodo in podzemno skladiščiti presežno toploto ali hlad.

Reinterpretaciji arhivskih podatkov in določitvi tras za snemanje (refleksijskih) seizmičnih profilov in drugih geofizikalnih preiskav (magnetotelurika, gravimetrija,…) naj sledi njihova izvedba, ki se nadgradi z izdelavo raziskovalnih vrtin. Pri vrtanju raziskovalnih vrtin se pridobijo jedra še ne dovolj poznanih kamnin in izvedejo meritve mineraloških, petrografskih, hidrogeoloških in geotermičnih lastnosti, ki skupaj omogočijo izdelavo zanesljivejšega 3D geološkega modela za pravilne bilančne in finančne izračune za projektiranje novih objektov (vrtin).

Slovenian urban areas are rarely explored deeper than (a few) hundred metres, where drinking groundwater and shallow geothermal energy sources are tapped. Exploration of the deep geological structure has been carried out mainly for evaluation of hydrocarbon and underground natural gas storage potential. Geothermal aquifers in NE Slovenia are located in the same area, but neither shallower (thermal water for direct use) or deeper (geothermal fluids for electricity production) than these already explored layers.

We therefore propose systematic deep investigations with a depth range of 2 to 5 km to answer the current energy challenges: a) whether there are suitable geothermal aquifers beneath major cities that need to change heating sources for district heating systems, b) where are suitable resources for geothermal electricity generation, and c) where it is most economical to use thermal water and store excess heat or cold in the subsurface.

The reinterpretation of archive data and the definition of lines for geophysical (reflection) cross-sections and other investigations (magnetotellurics, gravimetry, etc.) should be followed by their implementation, and by the construction of exploratory boreholes. Their drilling will provide cores that are not yet sufficiently understood and measurements of mineralogical, petrographic, hydrogeological and geothermal properties, which together make it possible to produce a more reliable 3D geological model for the correct energy budget and financial assessment for the design of new facilities (boreholes).

Predlogi raziskovalnih poligonov

Regionalni geotermalni vodonosnik v Ptujsko-Grajski in Murski formaciji SV Slovenije: Vsaj 6 novih seizmičnih profilov dolžine 100 km v bližini obstoječih vrtin in območij s potencialom za pridobivanje in sezonsko skladiščenje geotermalne energije ter skladiščenje plinov z vsaj eno 2 km globoko raziskovalno vrtino za znižanje tveganja izgradnje reinjekcijskih vrtin.

Mestna občina Maribor: Vsaj 40 km seizmičnih profilov in ena raziskovalna vrtina globine 3-5 km za raziskave plitvega sedimentnega paketa, ki je morda primeren za podzemno skladiščenje toplote, ter hkrati zelo globokih razpokanih con v metamorfni podlagi, potencialno primernih za proizvodnjo geotermalne elektrike.

Mestna občina Ljubljana: Za raziskave strukture in debeline potencialno vodonosnih paleozojsko–mezozojskih kamnin v vzhodnem delu Ljubljane priporočamo okvirno 40 km seizmičnih profilov in vsaj eno 3-4 km globoko raziskovalno vrtino. Tu se izkazuje pozitivna geotermalna anomalija, možen je tudi potencial za podzemno skladiščenje plinov in toplote.

Širše območje Ljubljanske kotline: Na območju kotlin in alpskih dolin v primestjih večjih mest in občinah z dolgotrajno rastjo prebivalstva ter terciarnih dejavnosti je pomemben tudi potencial rabe plitve geotermije. Stihijski razvoj geotermalnih toplotnih črpalk lahko predstavlja vedno večjo stopnjo tveganja bodočih investicij, zato bi sistematične geološke in hidrogeološke raziskave prvih 250 m pod površjem olajšale razvoj in projektiranje sistemov rabe, tudi s podzemnim skladiščenjem energije, ter upravljanje in zaščito virov podzemne pitne vode

Proposals for exploration sites

Regional geothermal aquifer in the Ptuj-Grad and Mura Formations of NE Slovenia: At least 6 new seismic cross-sections of 100 km length in the vicinity of existing boreholes and areas with potential for geothermal energy production, seasonal heat or gas storage and with at least one 2 km deep exploration well to reduce the risk of new reinjection wells.

Municipality of Maribor: At least 40 km of seismic cross-sections and one 3-5 km deep exploratory borehole to investigate the shallow sedimentary package potentially suitable for underground thermal storage and at the same time very deep fractured zones in the metamorphic bedrock potentially suitable for geothermal power generation.

Municipality of Ljubljana: For investigations of the structure and thickness of potentially water-bearing Palaeozoic-Mesozoic rocks in the eastern part of Ljubljana, we recommend approximately 40 km of seismic cross-sections and at least one 3-4 km deep exploratory well. There is a positive geothermal anomaly in Ljubljana and also potential for underground gas and heat storage.

Wider Ljubljana Basin area: In the basins and alpine valleys in the suburbs of major cities and municipalities with long-term population growth and tertiary activities, the potential for shallow geothermal use is also significant. Uncontrolled growth of geothermal heat pump sector may pose an increasing risk to future investments and the management and protection of drinking groundwater resources. Systematic geological and hydrogeological investigations of the first 250 m below the surface would facilitate systematic development and design of such use systems, including underground heat energy storage.

Prednostna območja za direktno rabo

Analiza prednostnih območij je izdelana za primer gradnje industrijskih trajnih rastlinjakov s površino nad 150 m² in ogrevanjem na geotermalno energijo za tri občine: Beltinci, Dobrovnik in Turnišče.

Gradnja rastlinjakov je dovoljena le na območju stavbnih zemljišč z namensko rabo površin z objekti za kmetijsko proizvodnjo. Ta je določena v prostorskih aktih lokalnih skupnosti – občinskih prostorskih načrtih.

Rastlinjaki in globoke geotermalne vrtine za črpanje in reinjekcijo termalne vode se po gradbenem zakonu uvrščajo med **zahtevne gradbene objekte**. Za vrtine je potrebno pridobiti gradbeno dovoljenje ter izdelati revidiran rudarski projekt za izvedbo.

Upoštevali smo podatke, omejitve in pogoje za naslednje sloje: vodovarstvena območja, vodna telesa, vodna dovoljenja in koncesije za rabo vode, zbirka podatkov o površinskih vodah – hidrografija, hidrogeološka karta 1:250.000 IAH, hidrološki monitoring, kemijski monitoring ter padavinske postaje ARSO, območja poplavne nevarnosti, gospodarska javna infrastruktura, občinski prostorski načrti (kmetijska, gozdna, stavbna zemljišča), dejanska raba tal, državni prostorski načrt, Natura 2000, naravne vrednote, zavarovana območja narave, register nepremične kulturne dediščine, gozdni rezervati, varovalni gozdovi, plazljiva območja, erozijska območja, plazovita območja, PM 10, rudarske pravice, funkcionalno razvrednotena območja, ekosistemi, odvisni od podzemne vode, geotermalni potencial. Obravnavali smo tudi sloje, ki nimajo omejitev ali tu niso relevantni: sledilni preizkusi, IED register, odlagališča industrijskih in komunalnih odpadkov, register divjih odlagališč, emisije v vode iz industrijskih in drugih naprav, emisije iz komunalnih čistilnih naprav, SEVESO zavezanci in podnebni scenariji.

Prepovedano je graditi na območju državnih prostorskih načrtov, gospodarske javne infrastrukture in varovalnih pasov, območjih obstoječih stavb, vodnih in priobalnih zemljiščih, na vodovarstvenih območjih zavarovanih z občinskim Odlokom in območjih velike in srednje poplavne nevarnosti. Vrtine je sicer možno zgraditi tudi na območju srednje poplavne nevarnosti, če se v predhodnem postopku ugotovi, da presoja vplivov na okolje ni potrebna. Enako velja na vodovarstvenih območjih, kjer za VVO III ni podanih prepovedi ali dovoljevanja. Pomembno omejitev bo predstavljal status trajnih kmetijskih zemljišč.

Priporočeno je, da se pridobijo predhodne informacije o morebitnih pogojih, da so nove vrtine oddaljene najmanj 2 km od obstoječih geotermalnih vrtin s koncesijo in razvoj poteka v bližini obstoječe komunalne in cestne infrastrukture. **Funkcionalno razvrednotena območja v teh občinah niso dovolj velika za rastlinjake, so pa primerna za gradnjo vrtin**.

Največji potencial vseh občin je v geotermalnem vodonosniku Murske formacije. Globine vrtin lahko dosežejo od 900 do 2200 m; v teh globinah je pričakovana temperatura med 60 in 110 ºC. V vsaki občini je možno razviti vsaj še eno geotermalno lokacijo.

Pomemben potencial z nižjim tveganjem razvoja večjih projektov predstavlja skupen razvoj rabe plitve in globoke geotermalne energije, tudi s podzemnim skladiščenjem toplotne energije.

Občina Beltinci
Tu se nahaja ena neaktivna geotermalna vrtina. Ostale globoke vrtine so trajno opuščene. Gradnja rastlinjakov je prepovedana na 25 % površine, drugod je potrebno pridobiti mnenja ali soglasja. Podobno je za vrtine. Največji geotermalni potencial je v osrednjem in JV delu občine. Občina ima zelo velik potencial za še večjo rabo plitve geotermalne energije.

Občina Dobrovnik
V občini sta dve geotermalni vrtini, ena je proizvodna. Gradita se dve novi reinjekcijski vrtini. Gradnja rastlinjakov je prepovedana na 13 % površine, drugod je potrebno pridobiti mnenja ali soglasja. Podobno velja za vrtine. Največji geotermalni potencial je na vzhodnem in zahodnem delu občine, izven 2 km območja okoli proizvodne vrtine Do-3g. Raba plitve geotermalne energije v občini še ni dovolj razvita, potencial je velik.

Občina Turnišče
V občini sta dve geotermalni vrtini, ena je proizvodna. Gradnja rastlinjakov je prepovedana na 13 % površine. Ker karta nevarnosti poplav še ni izdelana, se bo ta delež morda povečal. Drugje je potrebno pridobiti mnenja ali soglasja, tudi za gradnjo vrtin. Največji geotermalni potencial je v južnem delu občine, izven 2 km radija okoli proizvodne vrtine Re-1g. Sistemov rabe plitve geotermalne energije je kar nekaj, a potencial še ni dovolj izkoriščen.

Go-to areas for direct use

The analysis of go-to areas has been conducted for the construction of industrial permanent greenhouses with a surface area of over 150 m² and geothermal heating in three municipalities: Beltinci, Dobrovnik, and Turnišče.

The construction of greenhouses is only permitted in the declared area of building land with dedicated land use with facilities for agricultural production. This designation is determined in relevant local planning acts - municipal spatial plans.

Greenhouses and deep geothermal wells for the extraction and reinjection of thermal water are classified as **demanding facilities** according to the Construction Act. A building permit must be obtained for the wells, and a revised mining project for implementation prepared.

We accounted for data, limitations and conditions in he following layers: water protection areas, water bodies, water permits and concessions for water use, surface water database - hydrography, hydrogeological map 1:250,000 IAH, hydrological monitoring, chemical monitoring, and rainfall stations of Slovenian Environment Agency, flood hazard areas, economic public infrastructure, municipal spatial plans (agricultural, forest, building land), actual land use, national spatial plan, Natura 2000 protection areas, natural values, protected nature areas, register of immovable cultural heritage, forest reserves, protection forests, areas with mass movements, erosion areas, landslide areas, PM 10 areas, mining rights, functionally degraded areas, ecosystems dependent on groundwater, and geothermal potential. The following layers were also used, for which limitations are not specified or are not relevant here: tracer tests, IED register, industrial and municipal waste disposal sites, register of wild disposal sites, emissions to water from industrial and other devices, emissions from municipal sewage treatment plants, SEVESO taxpayers and climate scenarios.

The construction is forbidden in the area of national spatial plans, public economic infrastructure and safety zones, existing buildings, water and coastal lands, water protection areas protected by the Municipal Decree and in areas of high and medium flood risk. Wells can be constructed in areas of medium flood risk, provided that the preliminary procedure determines that an environmental impact assessment is not required. The same applies to the water protection areas, where no prohibitions or restrictions are defined for the 3rd zone. A significant limitation will be the designation of permanent agricultural land.

It is recommended to obtain preliminary information on potential limitations and conditions, to ensure that new wells are at least 2 km away from existing ones with concessions, and that the development occurs near existing utility and road infrastructure. **While the functionally degraded areas in these municipalities are not large enough for greenhouses, they are suitable for the construction of wells**.

The greatest potential across all municipalities lies in the geothermal aquifer of the Mura Formation. Well depths can range from 900 to 2200 meters, with expected temperatures between 60 and 110°C at these depths. In each municipality, it is possible to develop at least one additional geothermal site.

The combined use of shallow and deep geothermal energy in larger projects, including underground thermal energy storage, shows a significant potential that can lower development risks.

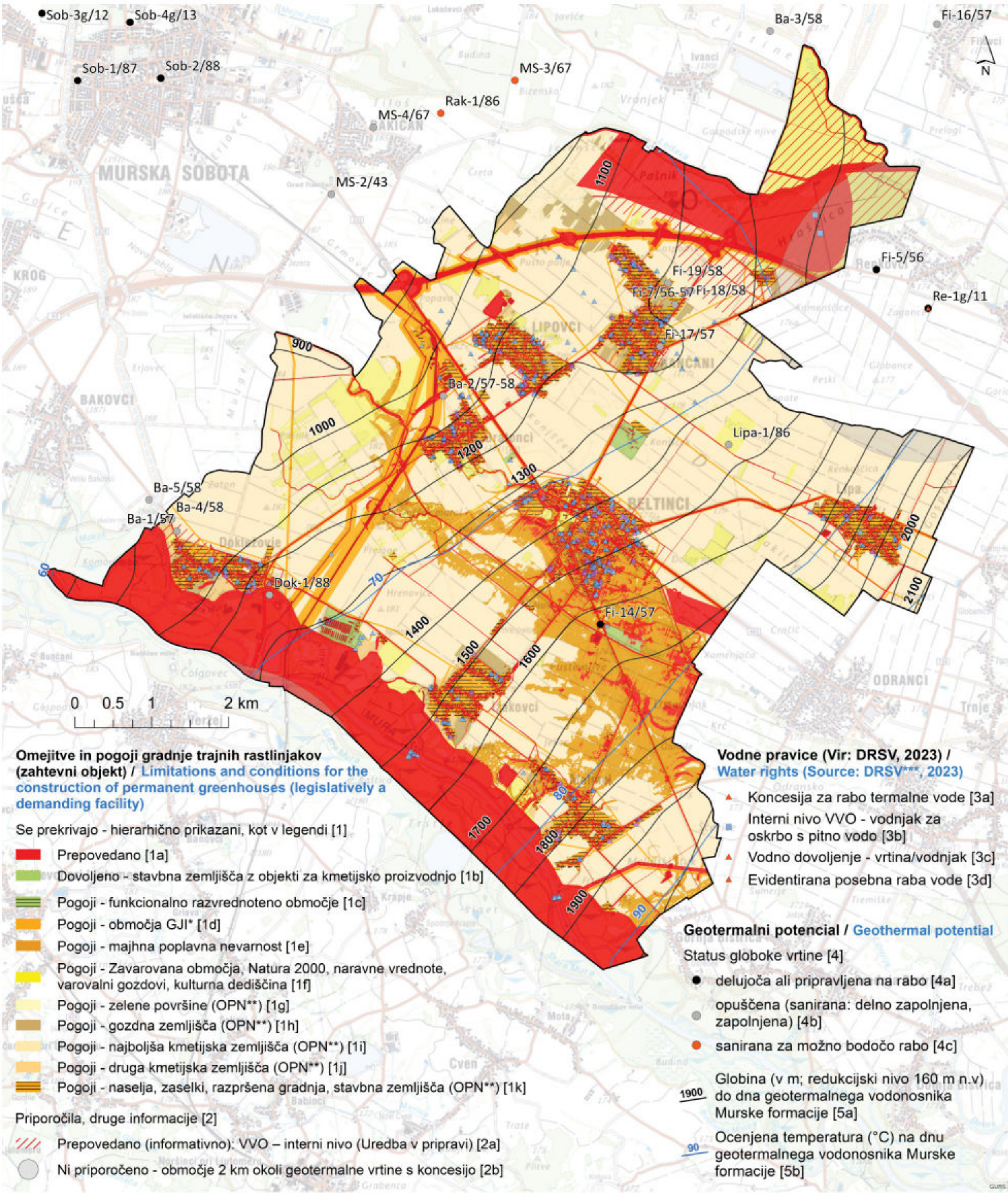
Municipality of Beltinci
There is one inactive geothermal well in this municipality. The others have been permanently decommissioned. Greenhouse construction is prohibited on 25% of the land, while elsewhere, opinions or approvals must be obtained. The same applies to wells. The highest geothermal potential is located in the central and southeastern parts of the municipality. The municipality holds significant potential for further utilization of shallow geothermal energy.

Municipality of Dobrovnik
The municipality has two geothermal wells, one of which is productive. Two new reinjection wells are currently under construction. Greenhouse construction is prohibited on 13% of the land, while elsewhere, opinions or approvals must be obtained. The same applies to wells. The greatest geothermal potential is in the eastern and western parts of the municipality, beyond the 2 km radius around the Do-3g production well. The use of shallow geothermal energy in the municipality is not yet fully developed, but the potential is considerable.

Municipality of Turnišče
There are two geothermal wells in the municipality, one of which is productive. Greenhouse construction is prohibited on 13% of the land. As the flood risk map has not yet been completed, this percentage may increase. Elsewhere, opinions or approvals must be obtained, including for well construction. The highest geothermal potential is in the southern part of the municipality, outside the 2 km radius around the Re-1g production well. There are several systems in place for utilizing shallow geothermal energy, but the potential is still underutilized.

Prednostna območja

Go-to areas



[1] Overlapping - hierarchically displayed, as in the legend; [1a] Prohibited; [1b] Permitted - the declared area of building land with dedicated land use with facilities for agricultural production; [1c] Conditions - Functionally degraded area; [1d] Conditions - Economic public infrastructure; [1e] Conditions - Low flood risk; [1f] Conditions - Protected nature areas, Natura 2000, Natural values, Protection forests, Cultural heritage; [1g] Conditions - Green areas (OPN); [1h] Conditions - Forest land (OPN); [1i] Conditions - Best agricultural land (OPN); [1j] Conditions - Other agricultural land (OPN); [1k] Conditions - Settlemets, hamlets, scattered buildings, building land; [2] Recommendations, other information; [2a] Prohibited (informatively) - WPA internal level (Regulation in preparation); [2b] Not recommended - area 2 km around geothermal well with concession; [3a] Concession for thermal water use; [3b] WPA internal level - Drinking water supply well; [3c] Water permit - borehole/well; [3d] Registered special water use; [4] Deep borehole status; [4a] Operational and ready to use; [4b] Abandoned (Decommissioning: partially filled, filled); [4c] Rehabilitated for possible future use; [5a] Depth (in m; reduction level 160 m a.s.l.) to the bottom of the geothermal aquifer Mura Formation; [5b] Estimated temperature (°C) at the bottom of the geothermal aquifer Mura Formation; GJI*... Economic public infrastructure; OPN**... Municipal Spatial Plan; DRSV***... Slovenian Water Agency.

Prednostna območja za direktno rabo termalne vode v Občini Beltinci
Go-to areas for direct use of thermal water in Municipality of Beltinci

GeoZS Geološki zavod Slovenije
REPUBLIKA SLOVENIJA MINISTRSTVO ZA OKOLJE, PODNEBJE IN ENERGIJO
REPUBLIKA SLOVENIJA MINISTRSTVO ZA NARAVNE VIRE IN PROSTOR
Skupnost občin Slovenije
HÁSKÓLINN Í REYKJAVÍK REYKJAVIK UNIVERSITY

Dostop do informacij

Pred izdelavo novih produktov smo pregledali javno dostopne podatke o geotermalnem potencialu Slovenije. Popisali smo pregledne objave v znanstveni reviji Geologija med leti 2002 in 2023, uredbe o koncesiji za rabo termalne vode in o rudarskih pravicah, spletne strani in portale evropskih projektov CO2StoP, DARLINGe, GeoConnect3d, GeoDH, GeoMol, GeoPLASMA-CE, HotLime, MUSE, SI-Geo-Electricity, T-JAM in Transenergy ter naslednje spletne strani:

- Geološki zavod Slovenije,
- eGeologija,
- Rudarska knjiga,
- Atlas okolja,
- Atlas voda,
- Slovenski okoljski javni sklad (Eko Sklad),
- Portal Enegetika,
- Geopedia,
- Pregledovalnik vrtin,
- Evropska infrastruktura geoloških podatkov (GIP-P; EGDI) in
- Atlas trajnostne energije Potenciali geotermije.

Večina podatkov je dostopna za severovzhodno Slovenijo, nekaj tudi za Krško-Brežiški bazen ali Ljubljano. Podatki so razdrobljeni, šibko ali ne- povezani in težko razložljivi za oceno geotermalnega potenciala.

Izboljšave spletnih strani lahko obsegajo izbiro bolj ustreznih ključnih besed za lažje iskanje, navedbo referenc prikazanega gradiva, več grafičnega in slikovnega materiala in zagotavljanje enakovrednosti slovenske in tuje (angleške) različice strani.

Priporočljiva je izdelava uradnega interaktivnega nacionalnega pregledovalnika, kjer bodo prikazana območja z geotermalnim potencialom in arhivski podatki vrtin in profilov z vsaj osnovnimi podatki (del informacij lahko ostane omejeno dostopnih, kot so to storili na Hrvaškem in Madžarskem).

Access to information

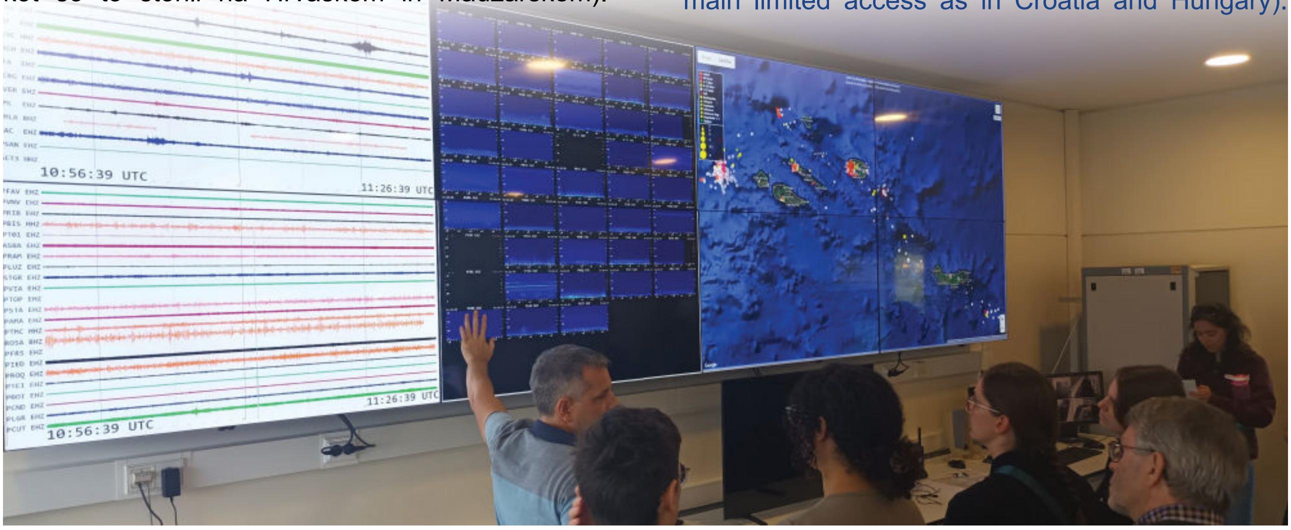
Before creating project deliverables, we reviewed publicly available data on Slovenia's geothermal potential. We listed open access papers in the scientific journal Geology between years 2002 and 2023, concession decrees for the use of thermal water and on mining rights, websites and portals of the European projects CO2StoP, DARLINGe, GeoConnect3d, GeoDH, GeoMol, GeoPLASMA-CE, HotLime, MUSE, SI-Geo-Electricity, T-JAM and Transenergy and the following websites:

- Geological Survey of Slovenia,
- eGeologija,
- Mining Registry Book,
- Environmental Atlas,
- Water Atlas,
- Slovenian Environmental Public Fund,
- Portal Enegetika,
- Geopedia,
- Borehole map viewer,
- European Geological Data Infrastructure, and
- Atlas of Sustainable Energy Geothermal potentials.

Most data is available for northeastern Slovenia, some for the Krško-Brežice basin or Ljubljana. The data are fragmented, weakly or uncorrelated and difficult to use for the assessment of geothermal potential.

Improvements of websites may include the selection of more relevant keywords for easier search, the listing of references of reported materials, more graphics and pictures, and the equivalence of the Slovenian and foreign (English) language versions.

It is recommended to create an official interactive national viewer, where areas with geothermal potential and archive data of wells and cross-sections with at least basic data will be displayed (part of the information may remain limited access as in Croatia and Hungary).



Bilanca rabe geotermalne energije

Geothermal energy use budget

Delovna skupina za implementacijo **Evropskega strateškega načrta za energetsko tehnologijo** s področja geotermalne energije in evropski geotermalni sektor sta postavila cilje, da bi raba plitve in globoke geotermalne energije do leta 2050 pokrila vsaj 25 % potreb po ogrevanju in hlajenju stavb in rastlinjakov ter 5 % potreb po toploti v industriji. Ob tem bi lahko zagotovila do 10 % proizvodnje električne energije ter soproizvodnjo mineralov in kritičnih mineralnih surovin v vsaj 10 državah. Pomembno novo tehnologijo predstavlja sezonsko podzemno skladiščenje toplote ali hladu.

Slovenska strategija ogrevanja in hlajenja ocenjuje potencial rabe toplote iz globoke geotermalne energije za rabo v stavbah, storitvah in kmetijstvu na vsaj 300 GWh, kar pomeni skoraj podvojitev sedanjega obsega rabe. Z vzpostavitvijo proizvodnje geotermalne električne energije in z učinkovito kaskadno rabo se potencial lahko še bistveno poveča.

Skupna zmogljivost naprav z rabo plitve in globoke geotermalne energije v letu 2022 je bila **318,7 MW_t**. Skupna proizvodnja je bila 1850,4 TJ oz. 514 GWh oz. 46 ktoe. To je 0,72% bruto domače rabe energije na nivoju primarne oskrbe z energijo. Čeprav je bil delež instalirane kapacitete sistemov rabe termalne vode le 18,3%, je ta zagotovila 29,9% vse pridobljene energije. Ostalo je delež plitve geotermalne energije.

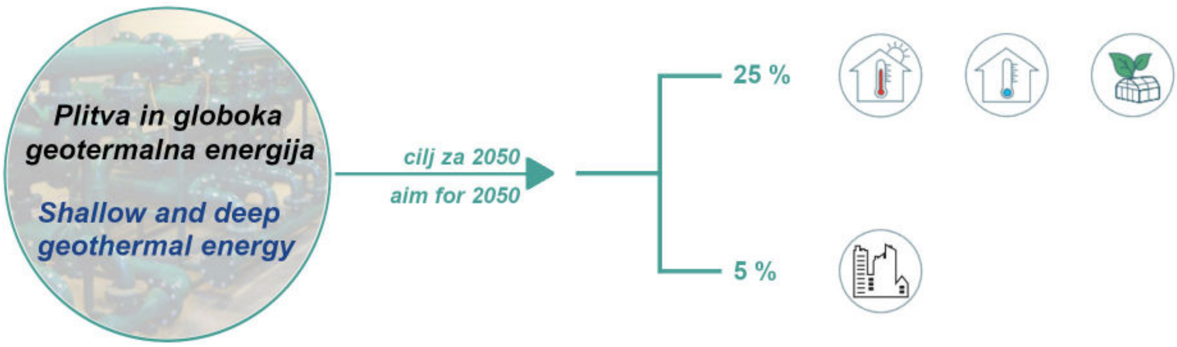
V letu 2023 so se količine nekoliko povečale, predvsem na račun rabe plitve geotermalne energije. Skupna zmogljivost se je povečala na 342,2 MW_t in skupna proizvodnja na 1998 TJ oz. 555 GWh. Delež na nivoju primarne oskrbe z energijo ostaja enak. Skupna zmogljivost **50 geotermalnih vrtin in 4 termalnih izvirov** pri 30 uporabnikih termalne vode in globoki geosondi v Benediktu je znašala 57,9 MW_t, izkoriščena energija pa 564,2 TJ oz. 156,7 GWh.

The **European Geothermal Strategic Energy Technology Plan** Implementation Task Force and the European geothermal sector have set targets for the use of shallow and deep geothermal energy to meet at least 25% heating and cooling needs for buildings and greenhouses, and 5% heating needs in industry by 2050. At the same time, geothermal energy could provide up to 10% electricity, and co-generation of minerals and critical minerals in at least 10 countries. Seasonal underground storage of heat or cold is an important new technology.

The Slovenian Heating and Cooling Strategy estimates the potential of deep geothermal energy for buildings, services and agriculture at more than 300 GWh, almost double the current use. The potential can be significantly increased by establishing the geothermal electricity generation and efficient cascade use.

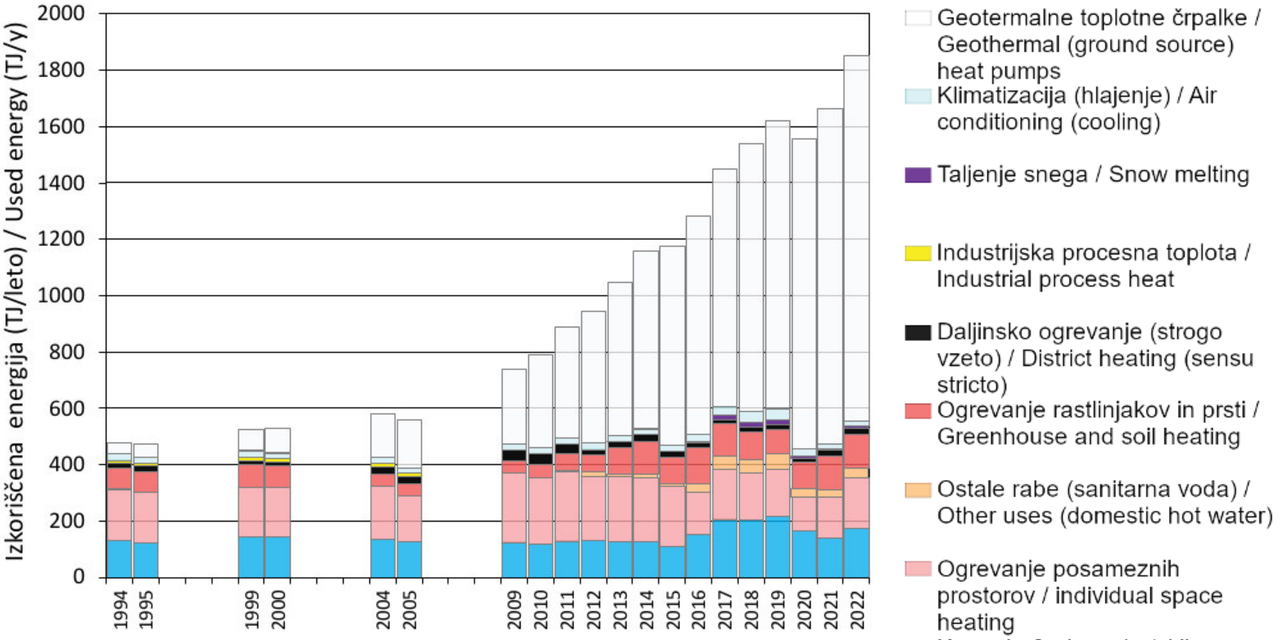
The total capacity of shallow and deep geothermal installations in 2022 was **318.7 MW_t**. The total production was 1850.4 TJ or 514 GWh or 46 ktoe. This is 0.72% of gross domestic energy consumption at primary energy supply level. Although the share of installed capacity of thermal water was only 18.3%, it provided 29.9% of the total energy generated. The rest is the share of shallow geothermal energy.

In 2023, the production increased slightly, mainly due to the use of shallow geothermal energy. Total capacity increased to 342.2 MW_t and total production to 1998 TJ or 555 GWh. The share at primary energy supply level remains the same. The total capacity of the **50 geothermal wells and 4 thermal springs** at 30 thermal water users plus the deep geoprobe in Benedikt amounted to 57.9 MW_t and the energy produced to 564.2 TJ or 156.7 GWh.



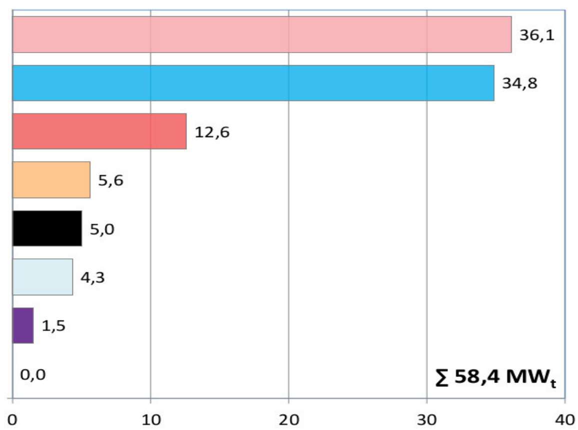
Termalna voda se uporablja predvsem za kopanje in plavanje z balneologijo ter ogrevanje individualnih prostorov in rastlinjakov. Ostale rabe so manjše. Čeprav je v Sloveniji 111 distribucijskih sistemov daljinskega ogrevanja in hlajenja, le dva, s skupno kapaciteto 2,7 MW_t, uporabljata geotermalno energijo - v Lendavi se uporablja geotermalni dublet, v Benediktu pa zaprt sistem globoke geosonde v geotermalni vrtini.

Thermal water is mainly used for bathing and swimming with balneology and for heating individual buildings and greenhouses. Other uses are minor. Although there are 111 district heating and cooling distribution systems in Slovenia, only two, with a total capacity of 2.7 MW_t, use geothermal energy – with a geothermal doublet in Lendava and with a deep geoprobe in Benedikt.



Proizvedena oz. uporabljena plitva in globoka geotermalna energija v Sloveniji po tipih rabe in letih, obdobje 1994-2022
Produced or used shallow and deep geothermal energy in Slovenia by types of use and years, period 1994-2022

Bilten Mineralne surovine
Bulletin Mineral Resources



Delež inštalirane zmogljivosti za rabo termalne vode v letu 2022 (%)
Share of installed capacity for use of thermal water in 2022 (%)

Količine termalne vode

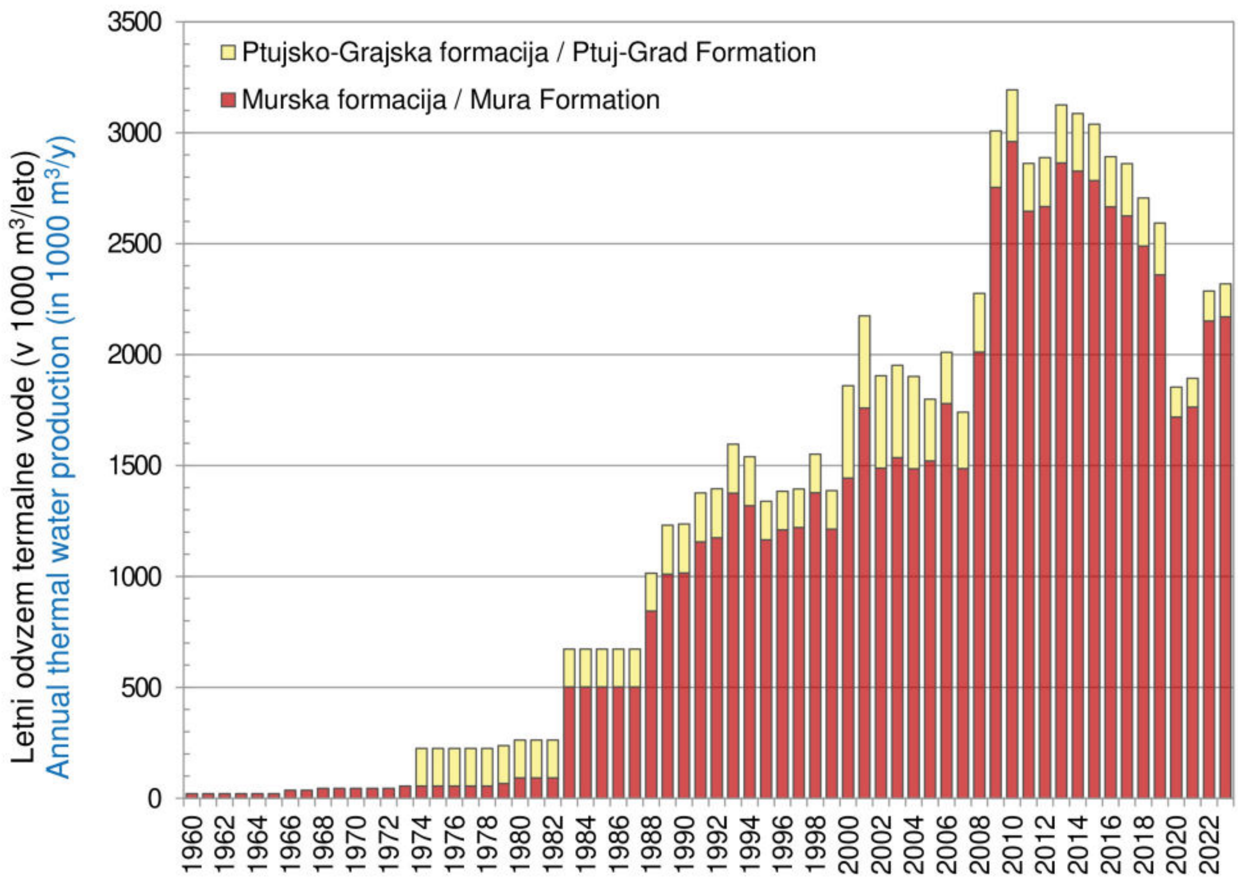
Thermal water quantities

Količino pridobljene termalne vode v Sloveniji ocenjujemo vsako leto z dvema pristopoma. Agencija Republike Slovenije za okolje (ARSO) analizira podatke zbranih obratovalnih monitoringov, Geološki zavod Slovenije (GeoZS) dopolni te informacije s prostovoljno poročanimi količinami, ki jih posredujejo koncesionarji po Zakonu o rudarstvu (ZRud-1) in tisti, ki ne izvajajo obratovalnega monitoringa.

Največji geotermalni potencial izkazuje SV Slovenija, kjer se na območju t.i. Mursko-Zalskega bazena termalna voda pridobiva iz štirih tipov vodonosnikov. Na Ptuju se izkorišča peščeno-prodnat vodonosnik v Ptujsko-Grajski formaciji, drugod se iz njega pridobiva hladna, pitna voda. Največ vrtin posega v regionalni in čezmejni geotermalni vodonosnik v slabo sprijetih peskih Murske formacije. Manjše količine se pridobijo tudi iz peščenjakov in apnencev Špiljske formacije ter razpokanih karbonatnih ali metamorfnih kamnin v podlagi Mursko-Zalskega bazena. Za to območje smo poskušali oceniti zgodovinski odvzem termalne vode, ki jih po letu 2009 dopolnjujemo z vse zanesljivejšimi meritvami količin.

The amount of thermal water extracted in Slovenia is estimated each year using two approaches. The Slovenian Environment Agency (ARSO) analyses the data collected from operational monitoring, and the Geological Survey of Slovenia (GeoZS) supplements this information with voluntarily reported abstractions provided by concessionaires under the Mining Act (ZRud-1) and those who do not carry out operational monitoring.

The largest geothermal potential is in NE Slovenia, where the thermal water is extracted from four types of aquifers in the so-called Mura-Zala Basin. In Ptuj, the sandy-gravely aquifer in the Ptuj-Grad Formation is exploited, while elsewhere cold, potable water is extracted from it. Most of the wells tap into the regional and cross-border geothermal aquifer in the loose sandstones of the Mura Formation. Smaller quantities are also extracted from the sandstones and limestones of the Špilje Formation and fractured carbonate or metamorphic rocks underlying the Mura-Zala Basin. For this area, the historical thermal water extraction is evaluated and supplemented by increasingly reliable measurements since 2009.



Zgodovinski trend odvzema termalne vode iz dveh glavnih geotermalnih vodonosnikov v SV Sloveniji (vir: GeoZS)
Historical trend of thermal water production from two main geothermal aquifers in NE Slovenia (source: GeoZS)

Zaradi nadgradnje obratovalnih monitoringov se zanesljivost ocene stanja vsako leto izboljšuje. Količina pridobljene termalne vode se je po letu 2015, ko je bila sklenjena večina koncesijskih pogodb po Zakonu o vodah (ZV-1), zaradi doslednega nadzora in povečanja energetske učinkovitosti sistemov rabe stalno zmanjševala. Zaradi začasnega zaprtja zdravilišč in kopališč v koronskem letu 2020 so bile takrat načrpane najmanjše količine v zadnjem desetletju, ki pa se zopet povečujejo.

Due to the upgrading of operational monitoring, the reliability of geothermal aquifer quantity assessment improves every year. After 2015, when the majority of concession contracts under the Water Act (ZV-1) were concluded, the thermal water abstraction steadily decreased due to consistent control and increased energy efficiency of the use systems. Due to the temporary closure of spas and baths in the coronavirus year of 2020, the smallest volumes in the last decade were pumped at that time, but they are increasing again.

Tipično, pred-koronsko porabo termalne vode v Sloveniji ocenjujemo na 6,9 mio m^3/leto. Od tega je bilo približno 3,0 mio m^3/leto načrpanih v SV Sloveniji z 2,2 m^3/leto iz Murske formacije (brez upoštevanja dubleta). Približno 0,95 mio m^3/leto so načrpali v Krško-Brežiškem bazenu.

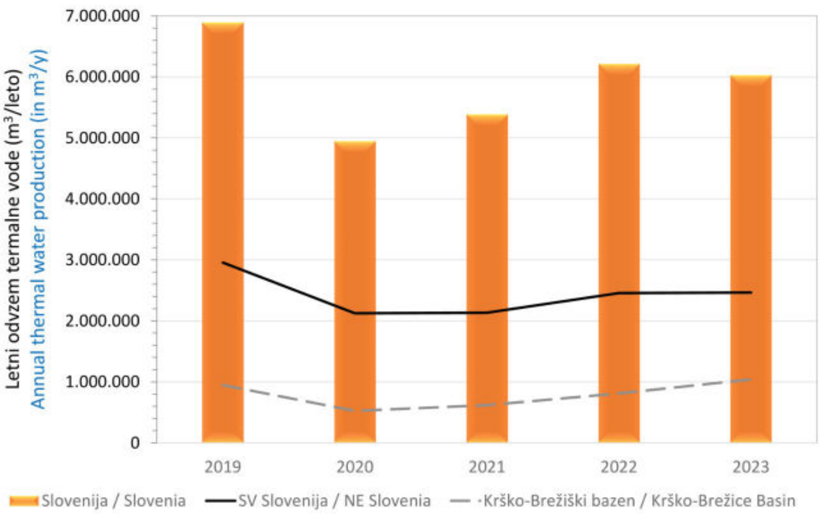
The typical, pre-coronavirus abstraction of thermal water in Slovenia is estimated at 6.9 million m^3/year. Among this, approx. 3.0 million m^3/year was produced in NE Slovenia with 2.2 million m^3/year of it from the Mura Formation (doublet not accounted for). About 0.95 million m^3/year was extracted in the Krško-Brežice Basin.

Odvzemi v letih 2022-2023 še niso dosegli pred-koronskih količin, saj je bila skupna količina termalne vode največ 6,2 mio m^3/leto, od tega do 2,5 mio m^3/leto v SV Sloveniji in 1,1 mio m^3/leto v Krško-Brežiškem bazenu. Iz Ptujsko-Grajske formacije v SV Sloveniji so v letu 2023 pridobili 0,15 mio m^3, iz Murske formacije pa 2,1 mio m^3 (brez upoštevanja dubleta).

Withdrawals in 2022-2023 did not reach pre-coronavirus amounts, as the total abstraction was a maximum of 6.2 million m^3/year, of which up to 2.5 million m^3/year in NE Slovenia and 1.1 million m^3/year in the Krško-Brežice Basin. In 2023, the Ptuj-Grad Formation in NE Slovenia produced 0.15 million m^3 of thermal water and the Mura Formation 2.1 million m^3 (doublet not accounted for).

Po podatkih MNVP je trenutno 34 nosilcev koncesije za rabo termalne vode po Zakonu o vodah, ki lahko skupaj pridobijo do 9,9 mio m^3 termalne vode na leto. Od tega je v SV Sloveniji dovoljen odvzem 3,5 mio m^3/leto, od tega 0,7 mio m^3/leto iz Ptujsko-Grajske formacije in 2,5 mio m^3/leto iz Murske formacije, brez upoštevanja dubleta. V Krško-Brežiškem bazenu je dovoljen odvzem do 1,6 mio m^3/leto. Po Zakonu o rudarstvu je podeljena ena koncesija za geotermični energetski vir v Lendavi, v letni količini 1 mio m^3/leto, in s 100% reinjekcijo.

According to the MNVP ministry, there are currently 34 concessions holders according to the Water Act, which together can abstract up to 9.9 million m^3/year of thermal water. Of this, 3.5 million m^3/year is permitted in NE Slovenia, with 0.7 million m^3/year from the Ptuj-Grad Formation and 2.5 million m^3/year from the Mura Formation (doublet not accounted for). Extraction up to 1.6 million m^3/year is permitted in the Krško-Brežice Basin. According to the Mining Act, one concession is granted for a geothermal energy source in Lendava, with an annual volume of 1 million m^3/year and 100% reinjection.



Količina odvzema termalne vode v Sloveniji in njenih dveh glavnih geotermalnih regijah med leti 2019-2023 (vir: GeoZS)
Thermal water abstraction in Slovenia and its two main geothermal regions between years 2019-2023 (source: GeoZS)

Stanje geotermalnih vodonosnikov
State of geothermal aquifers

ARSO letno vrednoti rezultate obratovalnih monitoringov. Redno objavlja monografijo Količinsko stanje podzemnih voda v Sloveniji - Poročilo o monitoringu in vsakih šest let poda sintezno oceno stanja in trendov za Načrt upravljanja z vodami. Kljub indikacijam o regionalnem zniževanju piezometrične gladine termalne vode v obdobju 2009-2019 in glede na takratne matematične modele, je bila v strokovnih osnovah za NUV III 2022-2027 (ARSO, 2021) podana ocena o količinskem stanju vodnega telesa Murska termalna voda kot dobro s srednjo stopnjo zaupanja.

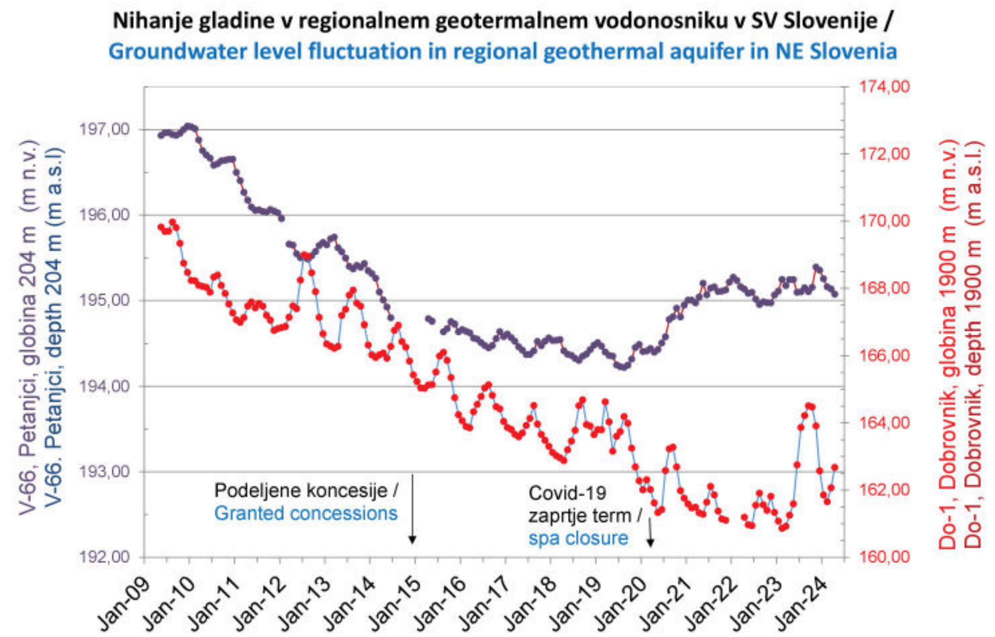
Vsako leto se novelira 3D hidrogeološki matematični model prenosa toka podzemne vode in toplote v globokem geotermalnem telesu podzemne vode SV Slovenije, s katerim se na osnovi podatkov o mesečnem odvzemu in povprečni gladini termalne vode ocenjuje razpoložljivo količino v regionalnem vodonosniku Murske formacije. Simulacije kažejo, da je za vzdrževanje regionalno stabilne gladine termalne vode najvišji priporočljivi skupni odvzem približno 2,3 milijona m³ na leto.

GeoZS že od maja 2009 izvaja raziskovalni monitoring geotermalnih vodonosnikov na opazovalnih vrtinah v Petanjcih in Dobrovniku, kjer urno beleži temperaturo in gladino podzemne vode. Trend zniževanja gladine se je upočasnil po letu 2015 in opazno stabiliziral po letu 2020, kar se opazi ne le na opazovalnih, ampak tudi na številnih proizvodnih vrtinah.

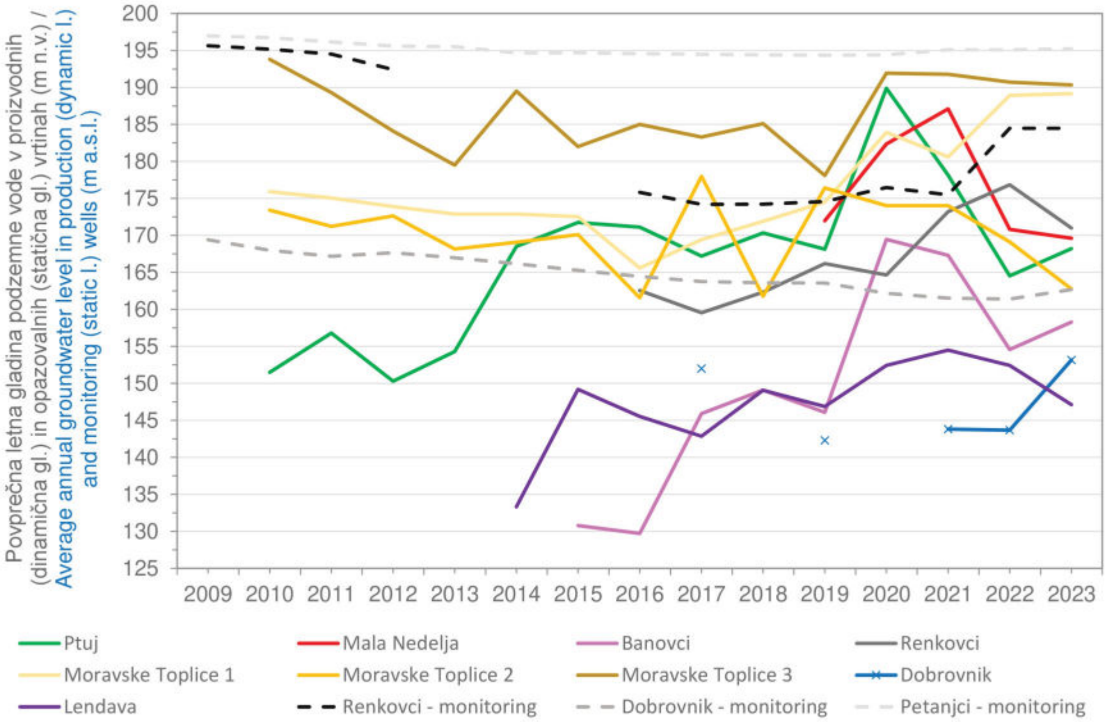
ARSO annually evaluates the results of operational monitoring. It regularly publishes the monograph Quantitative state of groundwater in Slovenia - Monitoring report and every six years provides a synthesis, assessing the state and trends for the Water Management Plan (NUV). Despite indications of a regional decrease in the piezometric levels of thermal water in the period 2009-2019 and according to the numerical models at the time, the expert basis for NUV III 2022-2027 (ARSO, 2021) gave an assessment of the quantitative state of the Mura Thermal Groundwater Body as good with medium level of confidence.

Every year, the 3D hydrogeological numerical model of groundwater flow and heat transfer in the deep geothermal groundwater body in NE Slovenia is updated with data on monthly abstraction and the average groundwater level of thermal water. It is used to estimate the available quantities in the regional aquifer of the Mura Formation. Simulations show that to maintain a regionally stable groundwater level, the maximum recommended total withdrawal is approximately 2.3 million m³ /year.

Since May 2009, GeoZS has been operating research monitoring of geothermal aquifers at two observation wells in Petanjci and Dobrovnik, where it records hourly temperatures and groundwater levels. The trend of lowering the water level slowed down after 2015 and stabilized noticeably after 2020, which is evident not only in observation but also in many production wells.



Trend mesečnih gladin v opazovalnih geotermalnih vrtinah v SV Sloveniji od 2009 do 2024 (vir: GeoZS)
Trend of monthly groundwater levels in observation geothermal wells in NE Slovenia from 2009 to 2004 (source: GeoZS)



Trend letnih gladin v geotermalnih vrtinah v SV Sloveniji od 2009 do 2023 (vir: GeoZS, ARSO)
Trend of yearly groundwater levels in geothermal wells in NE Slovenia from 2009 to 2023 (source: GeoZS, ARSO)

Pregledovalnik 3D geotermalnega modela
Webviewer of 3D geothermal model

3D digitalni geološki in geotermalni model severovzhodne Slovenije omogoča uporabnikom, da samostojno preverijo globino in temperaturo potencialnega rezervoarja na izbrani lokaciji.

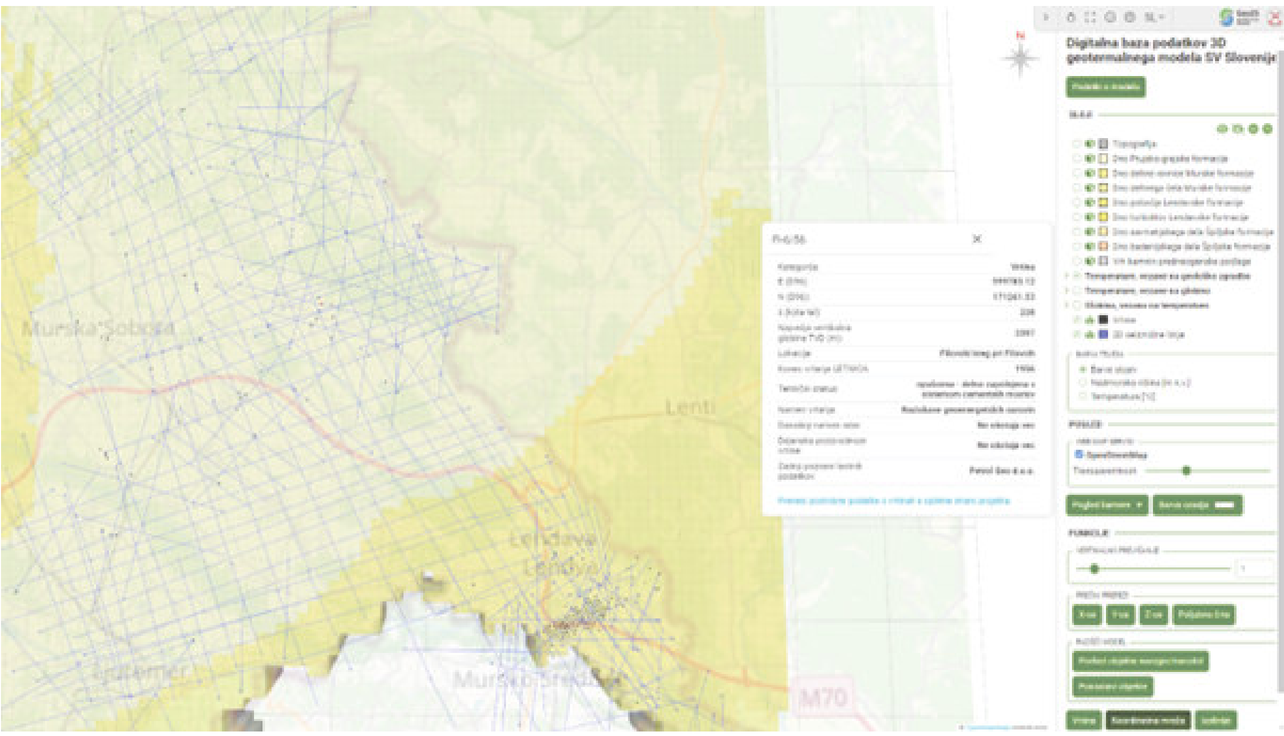
Regionalni modeli so primerni predvsem za pred-investicijske in orientacijske študije, niso pa zasnovani za natančno lociranje novih globokih vrtin!

Prikaz je na voljo v slovenskem ali angleškem jeziku in vključuje podatkovne sloje, ki so bili izdelani v projektih GeoMOL, TRANSENERGY, DARLINGe, iz arhiva GeoZS in iz ARSO matematičnega modela. Vsebuje tudi opis zanesljivosti podatka. Podatki so integrirani v 3D bazo Evropske geološke podatkovne infrastrukture (EGDI). Omogočen je izris temperatur in geoloških mej glede na navidezno vrtino ali prečni prerez ter prikaz lokacij in trajektorij obstoječih globokih vrtin in tras geofizikalnih profilov s prikazom podrobnih informacij. Rezultat je mogoče izvoziti v PDF format. Temperature so prikazane z izobatami po različnih globinah (do 5 km) kot tudi obratno – z izrisom globin, pri kateri temperatura dosega 30, 50, 75, 100, 125 in 150 °C (izoterme).

The 3D digital geological and geothermal model of northeastern Slovenia allows users to independently assess the depth and temperature of potential reservoirs at a selected location.

The regional models are primarily designed for pre-investment and orientation studies and are not intended for locating new geothermal wells!

The model is available in both, Slovenian and English, and includes data layers from the GeoMOL, TRANSENERGY, and DARLINGe projects, as well as archives from GeoZS and the ARSO mathematical model. It also provides a reliability assessment of the data. The data is integrated into the 3D database of the European Geological Data Infrastructure (EGDI). Users can visualize temperatures and geological boundaries based on a virtual well or cross-section, locations and trajectories of deep wells, and lines of geophysical cross-sections with detailed information. Results can be exported in PDF format. Temperatures are displayed by isobaths at various depths (up to 5 km) and vice versa – with a visualization of the depth at which the temperature reaches 30, 50, 75, 100, 125 and 150°C (isotherms).



Izgled pregledovalnika podatkov 3D geotermalnega modela SV Slovenije
Webviewer layout of 3D geothermal model of NE Slovenia

Podatki o globokih vrtinah

Date on deep boreholes

Z vrtanjem pridobimo številne točkovne informacije v 3D prostoru, hkrati pa se primerno zasnovane raziskovalne vrtine lahko uporabljajo tudi za proizvodnjo termalne vode.

Globoke vrtine so bile prvenstveno vrtane za raziskave nahajališč ogljikovodikov. Prva, globlja od 1000 m, je bila izvrtana v Dolini pri Lendavi leta 1942. Globina 3000 m je bila presežena v Gabrju pri Lendavi leta 1955, najgloblja pa je bila (danes opuščena) Ljut-1 s 4048 m, izvrtana na Kamenščaku pri Ljutomeru leta 1988. Prva namenska globlja vrtina za termalno vodo je bila izvedena v Čatežu leta 1971, v SV Sloveniji pa na Ptuju leta 1973. Čeprav je poznanih kar 551 vrtin, globljih od 500 m, so bile javno dostopne le njihove lokacije.

Zato prvič objavljamo metapodatke o 265 globokih (>500 m) vrtinah, ki so lahko pomembne za raziskave globokega geotermalnega potenciala. Od tega jih 245 leži v Mursko-Zalskem bazenu v SV Sloveniji. Njihova skupna vertikalna globina (TVD) je bila 478,8 km, od tega 95% pripada SV Sloveniji. Zaradi trajne opustitve kar 166 (63%) vrtin je trenutno dostopna skupna globina le 143,7 km. Od tega je le še 16 vrtin globljih od 2 km, približno 60 vrtin pa jih ima globino med 1 in 2 km.

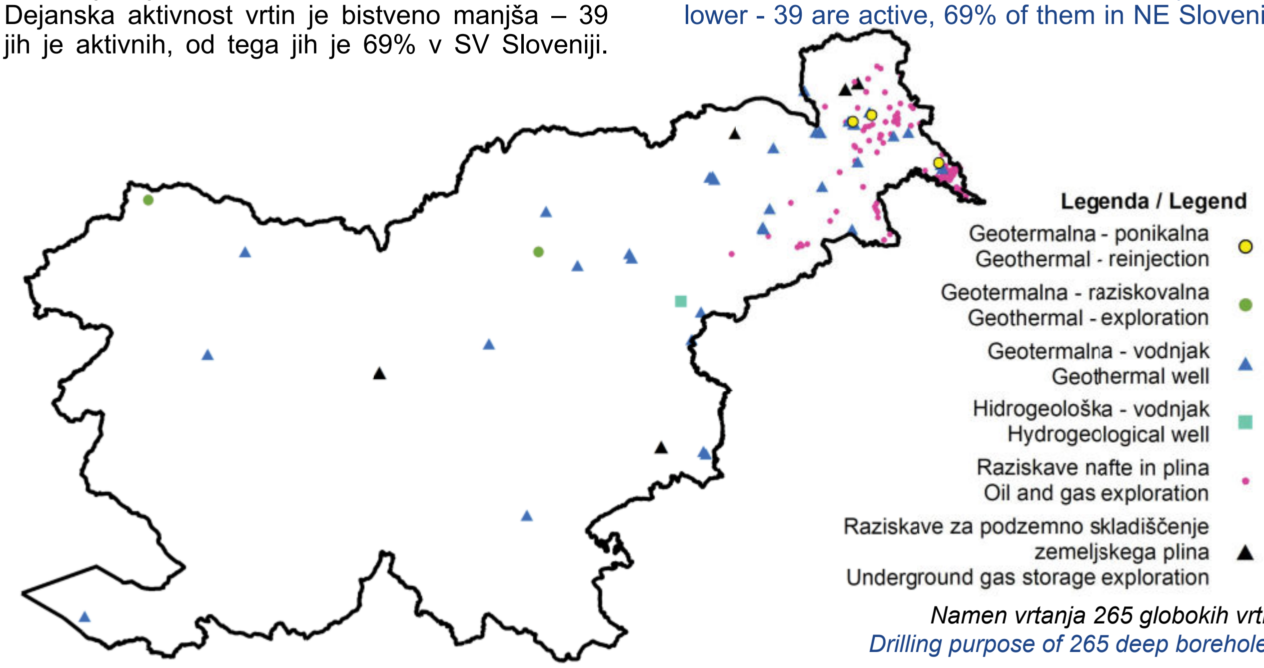
Največ vrtin (214) je bilo izvrtanih za raziskave ogljikovodikov, pet za raziskave podzemnega skladiščenja zemeljskega plina, od tega so tri v SV Sloveniji. Ostale so bile izvedene za raziskave termalne vode, od tega le tri za vračanje toplotno izrabljene termalne vode nazaj v vodonosnik (reinjekcijo). Danes jih 11 še lahko proizvaja nafto, 13 zemeljski plin, 59 termalno vodo, 2 lahko delujeta kot reinjekcijski vrtini, 7 pa kot opazovalne vrtine. Dejanska aktivnost vrtin je bistveno manjša – 39 jih je aktivnih, od tega jih je 69% v SV Sloveniji.

Drilling provides valuable point information in 3D space, but well-designed exploratory boreholes can also be used to produce thermal water.

Deep wells were primarily drilled for hydrocarbon exploration. The first borehole deeper than 1000 m was drilled in Dolina near Lendava in 1942. The depth of 3000 m was exceeded in Gabrje near Lendava in 1955, and the deepest Slovenian (now abandoned) borehole is Ljut-1 with 4048 m, drilled at Kamenščak near Ljutomer in 1988. The first dedicated deep borehole for thermal water was drilled in Čatež in 1971 and in NE Slovenia in Ptuj in 1973. Although 551 boreholes deeper than 500 m are known, only their locations are publicly available.

For the first time, we are publishing metadata on 265 deep (>500 m) boreholes that may be relevant for research on deep geothermal potential. Of these, 245 are located in the Mura-Zala Basin in NE Slovenia. Their total vertical depth (TVD) was 478.8 km, of which 95% belonged to NE Slovenia. Due to the permanent abandonment of 166 (63%) boreholes, the total accessible depth is currently only 143.7 km. Of these, only 16 boreholes are deeper than 2 km, while approximately 60 boreholes are between 1 and 2 km deep.

Most boreholes (214) were drilled for hydrocarbon exploration and five for underground natural gas storage, of which three are in NE Slovenia. The rest were drilled for thermal water exploration, of which only three are reinjection wells for returning waste thermal water back into the aquifer. Today, 11 boreholes are still capable of producing oil, 13 natural gas, 59 thermal water, 2 can operate as reinjection wells and 7 as observation wells. Their actual activity is much lower - 39 are active, 69% of them in NE Slovenia.



Namen vrtanja 265 globokih vrtin
Drilling purpose of 265 deep boreholes

Podatki o geofizikalnih profilih

Date on geophysical cross-sections

Dostopnost podatkov o geološki sestavi podpovršja je ključnega pomena za opredelitev območij z največjim geotermalnim potencialom in potreb po nadaljnjih raziskavah.

V Poročilu o oceni razpoložljivih podpovršinskih podatkov in opredelitev območij, kjer so potrebne nadaljnje raziskave, so opisani rezultati več projektov in spletnih portalov: SI-Geo-Electricity, DARLINGe, GeoMol, Transenergy, GeoDH, HotLime, GeoConnect3d, T-JAM, GeoPLASMA-CE, MUSE, GRETA, LEGEND, CO2StoP, eGeologija, Geotermija, GIP-P (Evropa) in Pregledovalnik vrtin.

Največjo zanesljivost ocene geotermalnega potenciala dosežemo z razpoložljivimi podatki na lokaciji, ki nas zanima. Zmanjšanje geološkega tveganja pri izgradnji novih vrtin lahko dosežemo z izvedbo regionalnih raziskav, pri čemer je najpogosteje mišljena izvedba globokih geofizikalnih seizmičnih raziskav v potrebni natančnosti in globinskem dosegu. V Sloveniji so bile takšne raziskave izvedene predvsem za iskanje rezervoarjev ogljikovodikov in možnih podzemnih skladišč zemeljskega plina, najpogosteje s ciljno globino pod 3 km.

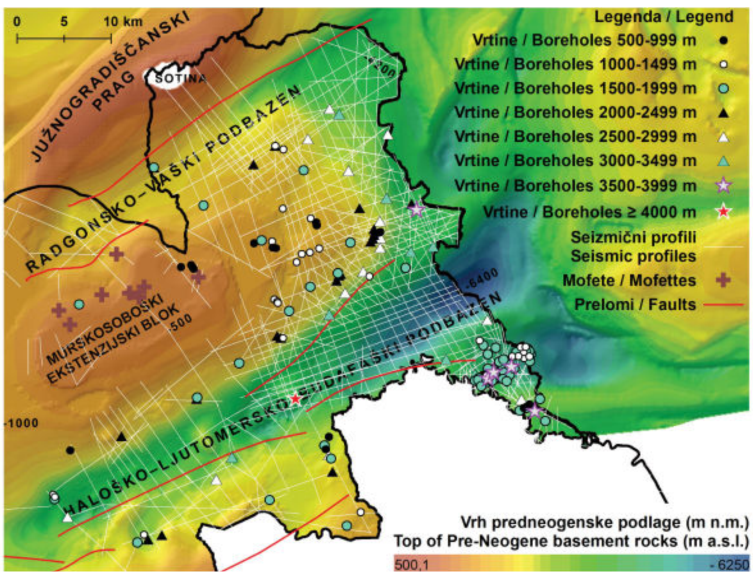
Objavili smo trase 330 2D refleksijskih seizmičnih profilov v SV Sloveniji, ki so nastali med leti 1971 in 1990 in pokrivajo skupno dolžino 3022 km. Zbrani so naslednji metapodatki: ID linije in oznaka profila, koordinatni sistem, način zajema koordinat in njegova natančnost, leto izvedbe profila, dolžina in globina profila, vrsta (SEG ali papirnata oblika), metoda meritve (op.p. vsi so refleksijski), ali obstajajo interpretirani podatki za namen geotermije, izvajalec in investitor meritev ter dostopnost. Vsi ti profili so v lasti Petrol Geo d.o.o.

The availability of data on the geological settings is crucial for identifying areas with the highest geothermal potential and also the ones needing further research.

The report on the assessment of available subsurface data and the identification of requirement for further research describes the results of several projects and web portals: SI-Geo-Electricity, DARLINGe, GeoMol, Transenergy, GeoDH, HotLime, GeoConnect3d, T-JAM, GeoPLASMA-CE, MUSE, GRETA, LEGEND, CO2StoP, eGeology, Geothermcs, GIP-P (Europe) and the e-Borehole.

The most reliable estimate of geothermal potential is achieved by having data available for the location of interest. Reducing the geological risk in the construction of new wells can be achieved by performing regional surveys, most often involving deep geophysical seismic surveys of the required accuracy and depth range. In Slovenia, such surveys have been carried out mainly for exploration of hydrocarbon reservoirs and underground natural gas storage, most often with a target depth below 3 km.

We have published the lines of 330 2D reflection seismic cross-sections in NE Slovenia, acquired between 1971 and 1990, and covering a total length of 3022 km. The following metadata are collected: line ID and name code, coordinate system, method of coordinate acquisition and its accuracy, year, length and depth, type (SEG or paper), and measurement method (all are reflection). Also included is whether the information is interpreted for geothermal purposes, the operator and investor of the measurements, and accessibility. All these cross-sections are owned by Petrol Geo d.o.o.



Globina popisanih vrtin v SV Sloveniji in trase seizmičnih profilov

The depth of listed boreholes in NE Slovenia and lines of seismic cross-sections

Digitalna baza podatkov 3D getermalnega modela SV Slovenije

Digital database of the 3D geothermal model of NE Slovenia

Slovensko združenje za geotermalno energijo
Slovenian Geothermal Energy Association

Namen

Osnovni namen nastajajočega združenja je pospešiti interdisciplinarno povezovanje in združevanje strok za hitrejši razvoj trajnostne rabe plitve in globoke geotermalne energije v Sloveniji.

Poslanstvo

Poslanstvo združenja je odprto, učinkovito in profesionalno delovanje na področju razvoja raziskav in rabe geotermalne energije. S tem se bo povečal delež nizkoogljičnih obnovljivih virov energije, izboljšala zaščita okolja in pospešil zeleni prehod energetskega sektorja.

Pripravljenost za sodelovanje v novem združenju so izrazila naslednja podjetja in posamezniki:

Purpose

The primary purpose of the emerging association is to accelerate interdisciplinary collaboration and integration of expertise to foster faster development of sustainable use of both, shallow and deep geothermal energy in Slovenia.

Mission

The mission of the association is to operate openly, efficiently, and professionally in the development, research, and utilization of geothermal energy. This will increase the share of low-carbon renewable energy sources, enhance environmental protection, and accelerate the green transition of energy sector.

The following companies and individuals are willing to participate in the new association:

- Atlas Trading d.o.o.
- GeoGreen d.o.o.
- Geološke storitve Geo-Rock, Jernej Kerčmar s.p.
- Geološki zavod Slovenije
- Inštitut za rudarstvo, geotehnologijo in okolje
- Kronoterm, d.o.o
- Lokalna energetska agencija za Pomurje
- Maja Turnšek
- Matej Koršič
- Peter Vesenjak
- VELING-DEOL d.o.o.
- VRTINA d.o.o.
- Zavod za gradbeništvo Slovenije.

Smernice za razvoj projekta
Guidelines for project development

Izvedba projekta geotermalnega dubleta s črpalno in reinjekcijsko vrtino ter površinskim sistemom rabe toplote in pripravo vode za vračanje v isti vodonosnik je zahtevna in dolgotrajna. Za uspešno izvedbo morajo sodelovati strokovnjaki geološke, rudarske, energetske, strojniške, procesno kemijske, elektro in gradbene stroke.

Področje urejajo trije zakoni, ki se med sabo prepletajo in dopolnjujejo, upoštevati pa jih je potrebno še nekaj več. Upravni postopki so načeloma jasni in potekajo po uradniški dinamiki. Hitrejšemu odločanju pripomore dobra obrazložitev načrtovanega posega in opis celovitosti in smiselnosti predvidenega posega v prostor. Projekti morajo biti razviti na trajnosten način, s čim manjšim vplivom na okolje v vseh fazah izvedbe.

Ključno je čimprej preveriti v kolikšni meri oziroma kako lahko naravne geološke in hidrogeološke danosti zadostijo načrtovanim energetskim potrebam.

Za izdelavo kvalitetne geotermalne vrtine so določene minimalne zahteve, ki so odvisne tudi od tipa vodonosnika. V kolikor zanesljive hidrogeološke informacije niso na voljo, je tveganje za tehnično neoptimalno zasnovano vrtino veliko večje. Ustrezne karotažne meritve v času izvedbe vrtine, testiranje njene kapacitete in stalno spremljanje stanja na vrtini zagotavljata manj presenečenj in težav pri rednem delovanju sistema rabe in kasnejši opustitvi vrtine.

The implementation of a geothermal doublet, consisting of a production and reinjection well, along with the surface heat utilization system and water preparation unit before reinjection into the same aquifer, is a complex and time-consuming process. Success depends on the collaboration of experts in geology, mining, energy, mechanical engineering, process chemistry, electrical engineering, and civil engineering.

Project development is governed by three overlapping and complementary laws, with additional regulations to consider. Administrative procedures are generally clear and follow the standard official workflow. A well-reasoned explanation of the planned activities, including a comprehensive and logical assessment of their environmental impact, can expedite decision-making. Projects must be developed sustainably, minimizing environmental impacts at every stage of implementation.

It is crucial to assess, as early as possible, to what extent the natural geological and hydrogeological conditions can meet the planned energy requirements.

The minimum requirements for constructing a quality geothermal well are well-established and depend on the type of aquifer. Without reliable hydrogeological information, the risk of designing a technically suboptimal well increases significantly. Proper geophysical logging during drilling, well capacity testing, and continuous monitoring help reduce unexpected issues and operational challenges during regular use, as well as at the well's eventual decommissioning.

Smernice za reinjekcijo
Guidelines for reinjection

Reinjeciranje nadomešča odvzeto količino termalne vode v vodonosniku, da služi le kot prenosnik toplote na površje. Ta metoda je ključna za trajnostno in okolju prijazno rabo geotermalne energije, saj ohranja vodno bilanco in preprečuje izpuste odpadne vode v vodotoke.

Smernice vključujejo pregled ureditev priznanja reinjekcijskih vrtin v primerljivih državah, tehnična merila za izvedbo vrtin, predlagana hidrogeološka testiranja ter merila za razvrstitev vrtin glede na učinkovitost.

V letu 2023 je delovala le ena globoka reinjekcijska vrtina, v Lendavi. Demonstracijski reinjekcijski sistem, ki bi omogočil javni dostop do podatkov o obratovanju in ekonomiki, še ni bil vzpostavljen.

Vodna direktiva *a priori* ne zahteva reinjekcije, vendar moramo ohranjati dobro količinsko in kakovostno stanje vseh vodonosnikov. Direktiva o varstvu podzemnih voda pred onesnaževanjem dovoljuje reinjekcijo v isti vodonosnik, dodatno umetno napajanje vodonosnikov pa je dovoljeno le ob posebnih raziskavah in dovoljenjih.

V drugem Načrtu upravljanja voda (NUV II) je bil zaradi nepovratnega odvzema termalne vode in medsebojnih vplivov odvzemov uveden temeljni ukrep "b" R6b2, ki spodbuja reinjekcijo pri obstoječih uporabnikih v SV in JV Sloveniji. Obveznost reinjekcije se prav tako nanaša na povečanje obsega rabe pri obstoječih in novih vodnih pravicah. Reinjekcija kot pomembna tema upravljanja je prepoznana tudi v NUV III.

Reinjection replaces the volume of thermal water withdrawn from the aquifer, thus serving solely as a heat carrier to the surface. This method is crucial for the sustainable and environmentally friendly use of geothermal energy, as it maintains the water balance and prevents the discharge of wastewater into water bodies.

The guidelines include a review of the regulations governing the recognition of reinjection wells in comparable countries, technical criteria for drilling of wells, proposed hydrogeological testing, and criteria for classifying wells based on efficiency.

In 2023, only one deep reinjection well was operational, in Lendava. A demonstration reinjection system that would provide public access to data on operation and economics has not yet been established.

The Water Directive does not *a priori* require reinjection; however, we must maintain good quantitative and qualitative conditions for all aquifers. The Directive on the Protection of Groundwater Against Pollution permits reinjection into the same aquifer, while additional artificial recharge of aquifers is allowed only under specific studies and permits.

In the second Water Management Plan (NUV II), a fundamental measure "b" R6b2 was introduced due to irreversible withdrawals of thermal water and their interference, fostering reinjection among existing users in NE and SE Slovenia. The obligation for reinjection also applies to increase existing and for new water rights. Reinjection as a significant management issue is also recognized in the NUV III.

Smernice za učinkovito rabo

Guidelines for efficient use

Pri učinkoviti rabi geotermalne energije se vir izkorišča optimalno s stališča pretoka termalne vode in z največjim možnim izkoristkom temperature ter z vključevanjem drugih obnovljivih virov energije. **Kaskadna, zaporedna ali večstopenjska raba** predstavlja gospodaren in energetsko učinkovit način rabe toplotne energije ter ima manjši vpliv na okolje.

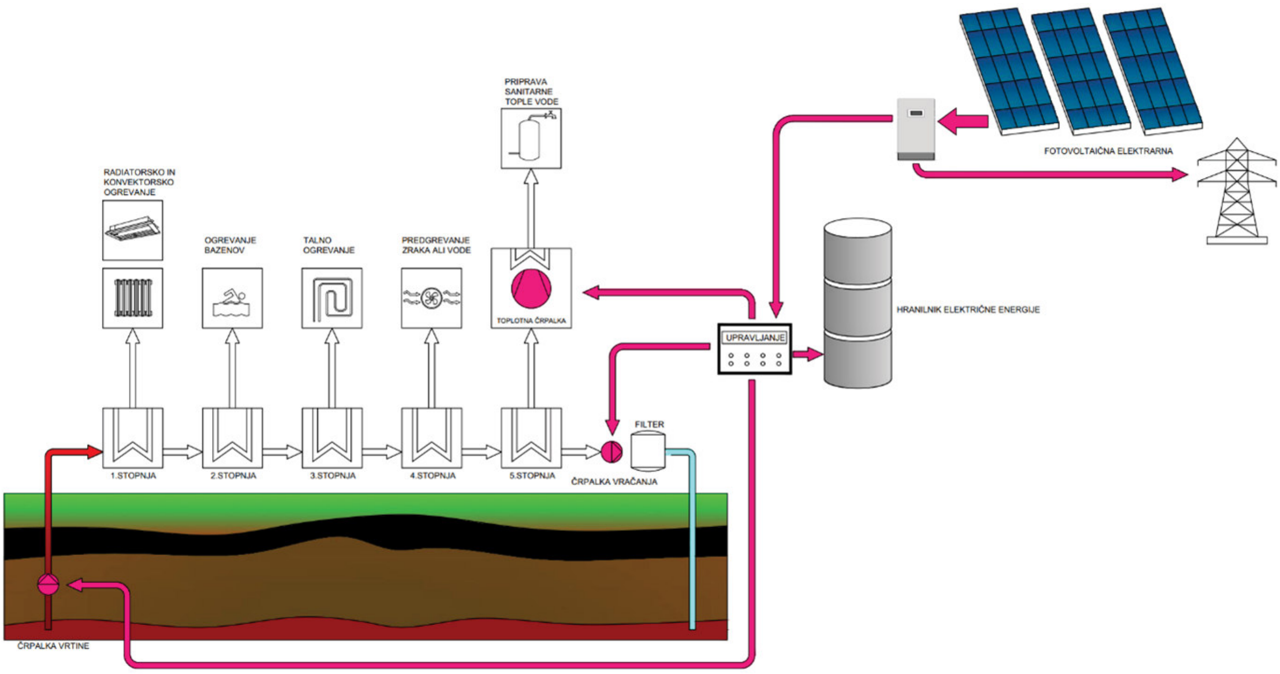
V smernicah so predlagana načela za kaskadno rabo termalne vode na več primerih. Poudarjajo pomen natančne ocene baznih in koničnih potreb po toploti ter temperaturnih nivojev predvidenih načinov rabe. Prav tako podajajo oceno potrebne električne energije za črpanje termalne vode, njeno reinjekcijo ter distribucijo skozi primarni ogrevalni sistem skupaj z oceno teh stroškov.

Idejna študija za Mestno občino Murska Sobota je ocenila potrebno toplotno moč za ogrevanje petih objektov (gledališča, gradu, zdravstvenega doma, igrišča za tenis ter prostorov in nogometnega igrišča NK Mura) na približno 2800 kW. To pri temperaturi termalne vode 50 ºC zahteva 34 l/s, kar lahko zagotovijo obstoječe, trenutno neaktivne vrtine. V naslednji fazi je potrebno vzpostaviti cevovod (vsaj) med vrtinama Sob-1 in Sob-4 ter namestiti filtrirno postajo pred bodočo reinjekcijsko vrtino. Sledi testiranje sistema za natančen izračun kapacitete. Nato se določi preostala potrebna infrastruktura in oprema za priklop posameznih uporabnikov ter možnost povezave sončnih elektrarn za delovanje črpalk in drugih porabnikov elektrike.

In the effective utilization of geothermal energy, the resource produces optimal water yield and maximum possible temperature difference is exploited, and involves an optimal combination of renewable energy sources. **Cascade, sequential, or multi-stage use** represents a cost-effective and energy-efficient method for harnessing thermal energy while minimizing environmental impact.

The guidelines propose principles for the cascade use of thermal water across various examples. They emphasize the importance of accurate assessments of baseload and peak heat requirements, as well as the temperature levels of the intended usage type. Additionally, they provide estimates for the electrical energy required for pumping thermal water, its reinjection, and distribution through the primary heating system, along with the cost assessment.

A feasibility study for the City Municipality of Murska Sobota estimated the necessary thermal power for heating five facilities (theatre, castle, health center, tennis courts, and NK Mura football pitch) at approximately 2800 kW. This requires 34 l/s of thermal water at a temperature of 50 °C, which can be supplied by the existing, currently inactive wells. In the next phase, a pipeline must be established (at least) between wells Sob-1 and Sob-4, and a filtration station should be installed before the future reinjection well. This will be followed by system testing to accurately calculate capacity. Subsequently, the remaining necessary infrastructure and equipment for connecting individual users will be defined, along with the potential for integrating solar power systems to operate pumps and other electrical consumers.



GeoZS Geološki zavod Slovenije
REPUBLIKA SLOVENIJA MINISTRSTVO ZA OKOLJE, PODNEBJE IN ENERGIJO
REPUBLIKA SLOVENIJA MINISTRSTVO ZA NARAVNE VIRE IN PROSTOR
Skupnost občin Slovenije Association of Municipalities and Towns of Slovenia
HÁSKÓLINN Í REYKJAVÍK REYKJAVIK UNIVERSITY

Smernice za binarno geotermalno elektrarno
Guidelines for binary geothermal power plant

Binarna geotermalna elektrarna za proizvodnjo električne energije ne uporablja termalne vode (125–150 °C) neposredno. V toplotnem izmenjevalcu se ta uporabi za uparjanje sekundarne delovne tekočine z nižjim vreliščem (na primer alkoholi ali organske spojine), ki nato poganja turbino in proizvaja električno energijo. Toplotno izrabljena termalna voda se po rabi vrne v isti vodonosnik.

Smernice opredeljujejo ključne korake za uspešno izgradnjo elektrarne. Pojasnjujejo faze razvoja projekta, potrebne postopke in dovoljenja ter sodelovanje s skupnostmi ter deležniki in obravnavajo pomisleke, povezane z morebitnimi vplivi na okolje. Zaradi prepletanja vsebin, kompleksnosti in dolgotrajnih postopkov je smiselno, da se vsaj prvi dve fazi izvajata sočasno.

Faza raziskav vključuje analizo omejitev rabe prostora ter izvedbo lokalnih študij geološkega potenciala z raziskovalnimi vrtinami in oceno kapacitete vira.

Faza umeščanja je najdaljša in se osredotoča na pridobivanje prostorskih in okoljskih dovoljenj, vključno s koncesijami.

Faza gradnje in obratovanja se prične z izdajo pravnomočnega gradbenega oziroma integralnega gradbenega dovoljenja. Poleg gradnje elektrarne se vzpostavi tudi ostala infrastruktura in dodatne vrtine. Med obratovanjem se izvajata monitoring stanja in optimizacija procesov.

Faza opustitve mora biti že v zasnovi projekta. Po koncu življenjske dobe se objekti opustijo, odstrani se vsa oprema, površina zemljišča se obnovi. S tem se prepreči onesnaženje ter zagotovi varnost in nadaljnja uporabnost okolja.

A binary geothermal power plant does not directly utilize thermal water (125–150 °C). Instead, it is used in a heat exchanger to vaporize a secondary working fluid with a lower boiling point (such as alcohols or organic compounds), which then drives a turbine to generate electricity. The utilized thermal water is reinjected back into the same aquifer.

The guidelines outline the key steps for successful construction of a power plant. They detail the phases of project development, necessary procedures and permits, and collaboration with communities and stakeholders, while addressing concerns related to potential environmental impacts. Given the interrelated nature of the content, its complexity, and the lengthy permitting processes, it is advisable for at least the first two phases to be carried out concurrently.

The research phase involves analysing constraints of spatial use and conducting local geological studies of potential through exploratory drillings and assessment of the capacity of resource.

The placement phase is the longest and focuses on obtaining spatial and environmental permits, including concessions.

The construction and operation phase begins with the issuance of a valid construction or integrated construction permit. In addition to building the power plant, the necessary infrastructure and additional wells are established. During operation, ongoing monitoring and process optimization are conducted.

The decommissioning phase must be integrated in the project design at start. At the end of the operational lifespan, the facilities are decommissioned, all equipment is removed, and the land is restored to prevent pollution and ensure safety and its future usability.

Zapiski ....

Notes ....

REPUBLIKA SLOVENIJA
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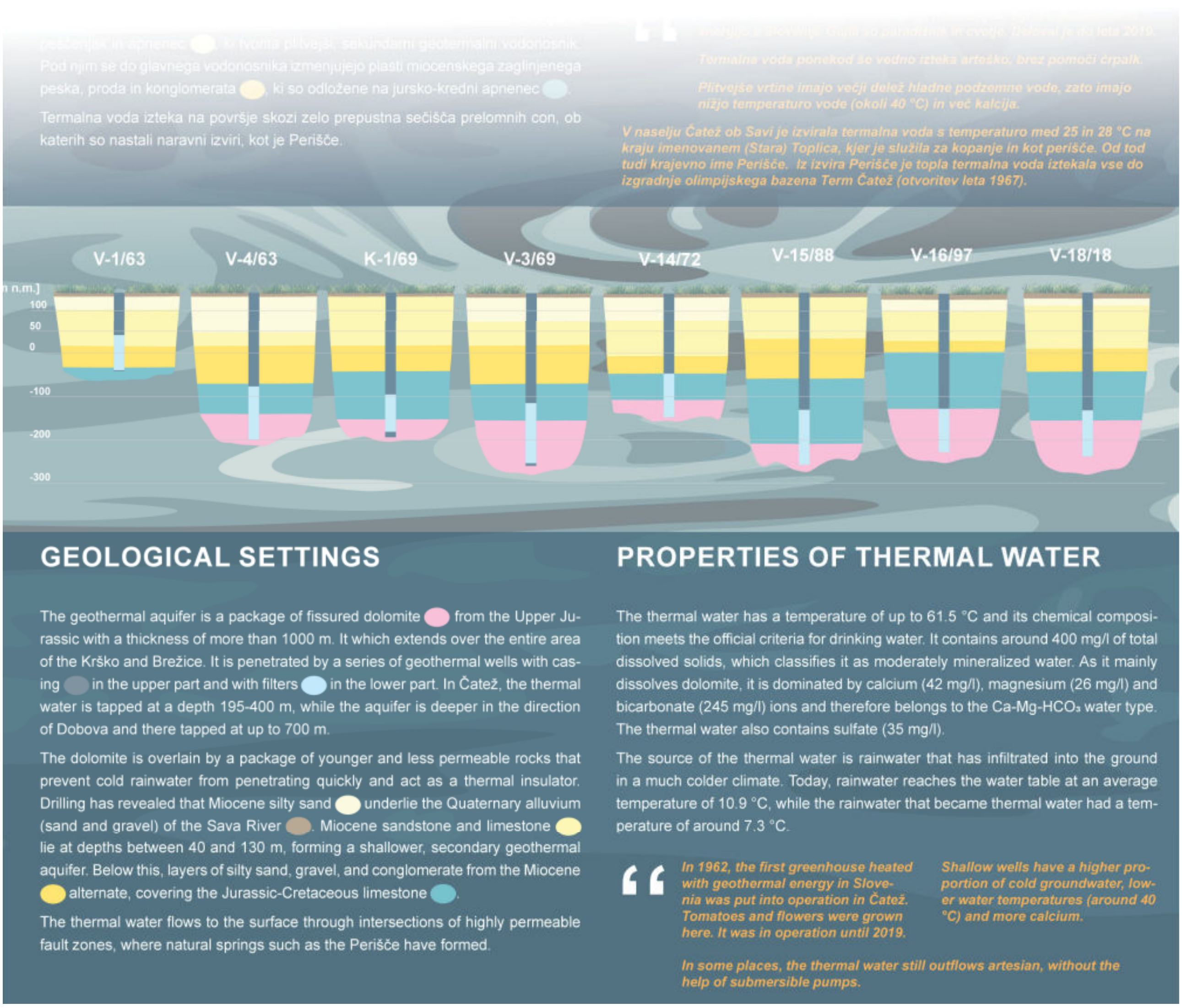
Informacijske table

Information boards

Na petnajstih lokacijah v Sloveniji so postavljene informacijske table, ki opisujejo učinkovito in kaskadno rabo geotermalne energije pri posameznih uporabnikih termalne vode. Obiskovalci kopališč in zdravilišč se lahko seznanijo z geološko zgradbo, lastnostmi in uporabo termalne vode. Pri vsaki lokaciji so izpostavljena zanimiva zgodovinska dejstva ali lokalne geotermalne posebnosti. Opisi so v treh jezikih - slovenskem, angleškem in nemškem oziroma na Obali tudi v italijanskem jeziku.

Information boards have been installed at fifteen locations across Slovenia, describing the efficient and cascade use of geothermal energy by individual users of thermal water. Visitors to spas and thermal resorts can learn about the geological structure, properties, and utilization of thermal water. Fascinating historical facts or local geothermal pecularities are also listed for each site. The descriptions are available in three languages – Slovenian, English, and German, with Italian instead of German on the Coast.

- Terme Banovci
- BIOTERME Mala Nedelja
- Grand Hotel Sava****sup Rogaška Slatina
- Hotel Cerkno
- Klevevška Toplica
- LifeClass Hotels & Spa Istrabenz Turizem d.d.
- Terme Dobrna
- Terme Dolenjske Toplice
- Terme Čatež
- Terme Ptuj
- Terme Snovik
- Terme Šmarješke Toplice
- Terme THERMANA Laško
- Terme Topolšica
- Terme 3000 Moravske Toplice



REPUBLIKA SLOVENIJA
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Projekt INFO-GEOTHERMAL
Project INFO-GEOTHERMAL

Izboljšati znanje in izkušnje / Improve know-how

- Delavnice, ekskurzije, poletna šola / Workshops, field trips, summer school
- Izobraževalni materiali / Educational materials
- Slovensko združenje za geotermalno energijo / Slovenian geothermal energy association

Povečati dostopnost informacij / Incerase availability of information

- Pregled (spletnih) orodij / Overview of (web)tools
- Metapodatki o vrtinah in geofiziki / Metadata on boreholes and geophysics
- Go-to območja za geotermalne projekte / Go-to-areas for geothermal projects
- Smernice za razvoj projekta / Guidelines on project development

Predlagati zakonodajne izboljšave / Suggest amendments of legislation

- Protokoli za vse na enem mestu / Protocols for one-stop-shop
- Za sheme geološkega tveganja / For geological risk schemes
- Za sheme za reinjektiranje, kaskadno uporabo in elektriko / For schemes for reinjection, cascade use and electricity

INFO-GEOTHERMAL spletna stran

INFO-GEOTHERMAL website

Digitalna baza podatkov 3D getermalnega modela SV Slovenije
Digital database of the 3D geothermal model of NE Slovenia

Bilten Mineralne surovine
Bulletin Mineral Resources

Spletni portal eGeologija

eGeologija web portal

Digitalna baza podatkov Pregledovalnik vrtin e-Vrtine
Borehole map viewer

GeoZS Geološki zavod Slovenije
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