# TOPLOTNE PUMPE

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***Izvorni naučni rad***

**Sažetak**

*Toplotne pumpe ili dizalice topline su uređaji koji imaju sposobnost prenosa energije. Pumpe prenose energiju koju uzimaju iz spoljašne i prebacuju je u unutrašnost objekata odnosno na mjesta u kojima je potrebno grijanje ili hlađenje. Toplotna pumpa se sastoji od sljedećih dijelova: kompresor, ventil za ekspanziju, gas (na primjer R410) odnosno fluid za prenos topline, isparivač i parni kondenzator. Iz obnovljivih izvora (zemlja, voda, vazduh) energija ulazi u isparivač pumpe. Zatim kroz sistem cijevi, gas koji je preuzeo energiju ide u kompresor gdje rastu pritisak i temperatura. Sljedeći korak se dešava u zavorenom sistemu izmjenjivača u kome toplota gasa prelazi na sistem za grijanje/hlađenje. Nakon što preda toplotu, gas se vraća na svoju prvobitnu temperaturu i ponovo ide u isparivač kako bi proces počeo ponovo. Kako bi ih jednostavnije razvrstali prema kriterijumima od opšteg interesa, dijelimo ih prema: energentima iz prirode – besplatnim energentima koje koriste, snazi i karakteristikama. Na primjer prema energentima koje koriste (besplatnim/prirodnim) dijelimo ih na: toplotna pumpa zrak-voda, toplotna pumpa zemlja-voda i toplotna pumpa voda-voda. Toplotne pumpe u svom imenu imaju kombinaciju dvije sredine. Prva riječ označava energent koji se koristi, a druga prenosilac energije u instalaciji.*

***Ključne riječi: toplotna, pumpa, energija, grijanje, temperatura, venti***

# HEAT PUMPS

***Abstract:*** *Heat pumps or heat pumps are devices that have the ability to transfer energy. Pumps transfer the energy they take from the outside and transfer it to the inside of buildings, i.e. to places where heating or cooling is needed. The heat pump consists of the following parts: compressor, expansion valve, gas (for example R410) or heat transfer fluid, evaporator and steam condenser. Energy from renewable sources (earth, water, air) enters the pump evaporator. Then through the pipe system, the gas that has taken on the energy goes to the compressor where the pressure and temperature increase. The next step occurs in a welded exchanger system where the heat of the gas is transferred to the heating/cooling system. After giving up the heat, the gas returns to its original temperature and goes back to the evaporator to start the process again. In order to classify them more simply according to criteria of general interest, we divide them according to: energy sources from nature - free energy sources they use, power and characteristics. For example, according to the energy they use (free/natural) we divide them into: air-water heat pump, ground-water heat pump and water-water heat pump. Heat pumps have a combination of two meanings in their name. The first word indicates the energy used, and the second the energy transmitter in the installation.*

***Key words: thermal, pump, energy, heating, temperature, valve***

# 1 UVOD

Toplotna pumpa je električni uređaj koji toplinu izvlači s jedog mjesta i prenosi je na drugo. To nije nova tehnologija, koristi se širom svijeta desetljećima, a hladnjaci i klima uređaji najpoznatiji su primjeri.[17]

Hladnjaci i klima uređaji oba su primjera toplotne pumpe koje rade specifično u režimu hlađenja. Hladnjak je u osnovi izolirana kutija sa spojenim sistemom toplotne pumpe gdje se zavojnica isparivača nalazi unutar kutije, obično u odjeljku za zamrzavanje. Toplina se apsorbuje s ovom mjesta i prenosi van, obično iza ili ispod jedinice u kojoj se nalazi zavojnica kondenzatora. Slično tome, klima uređaj prenosi topliinu iz kuće van kuće.

Toplotne pumpe su uređaji koji koriste toplinu sadržanu u zraku kako bi zagrijali toplu vodu koja se koristi za grijanje i potrošnu toplu vodu u vašem objektu. Imaju visoko energentsku učinkovitost zbog koje spadaju u obnovljive izvore energije te u pravilu osiguravaju COP viši od 4. U tom slučaju toplotna pumpa može za svaki kW utrošene električne energije proizvesti 4 kW toplinske energije.

Zanimljivo je to da toplotna pumpa čak i pri temperaturama ispod 0°C može izvući toplinu iz okolnog zraka, azahvaljujući modernim inverterskim kompresorima, režim rada proteže se do čak -28°C (zahvaljujući primjerice kompresorima s flow-injection tehnologijom), čime je zasigurno funkcionisanje sistema bez obzira na poziciju objekta i vanjsku temperaturu. Budući da tlo i zrak vani uvijek sadrže malo topline, toplotna pumpa može dovoditi toplinu u kuću čak i tijekom hladnih zimskih dana. Zapravo, zrak na -18°C sadrži oko 85 posto topline koju je sadržavao na 21°C. Ciklus toplotne pumpe u potpunosti je reverzibilan pa može osigurati cjelogodišnju klimatsku kontrolu za vaš dom. Osim grijanja toplotna pumpa može i hladiti prostor, ako su ugrađeni potrošači koji mogu hladiti prostor (podno/zidno/stropno grijanje ili ventilokonvektori).
Najveću efikasnost postiže na objektima (novim) s visokim stepenom termoizolacije. Pri tome se sugeriše korištenje inertnih sistema grijanja (podno, strpno, zidno) koji zahtijevaju niže temperature koje znače[18] manje opterećenje vanjske jedinice i manju potrošnju struje.

Iako se toplotna pumpa prvenstveno koristi u sistemima grijanja, kod izvedbi gdje se toplina odvodi vodom ista se može iskoristiti i za prepremu potrošne tople vode (PTV). Tu se obično radi o uređajima manje nazivne snage od 2 do 12 KW i pogonske snage 0,6 do 5,2 kW i na taj način moguće je smanjiti potrošnju energije za pripremu PTV za 2/3.

Kada se spremamo na nove investicije, zamjenu starog ili za potrebe novog sistema grijanja, moramo se pitati koje su prednosti i dugoročna isplativost te odluke. Je li cijena toplotne pumpe opravdava investiciju radi

[17] https://issuu.com/ecos15/docs/ecos_news_88_web/s/17073794

[18] https://issuu.com/ecos15/docs/ecos_news_88_web/s/17073794

daljnje uštede? Je li bolje investrati sada pa izbjeći ponovnu zamjenu kada nas na to prisile zakonske izmjene? Koliko je realno vremena još ostalo do bitnijih promjena u cijenama energenata? Sve su to realna pitanja i više nisu samo hipotetska.

### 1.1 Upotreba toplotne pumpe u svijetu

Toplotna pumpa s izvorom zraka jedan su od najnaprenijih sistema grijanja koji su dostupni vlasnicima kuća i firmama. S razlogom se na primjer u Švicarskoj svaka treća novogradnja oprema nekom od tipova toplotne pumpe, u Švedskoj 7 od 10 novogadnji, a u Njemačkoj i Islandu jedna četvrtina. U mnogim državama se traže ili već donose novi zakoni po kojima se odustaje od plinskih priključaka na novogradnji u bliskoj budućnosti. U Njemačkoj mora biti dostupan energetskij certifikat za svaku zgradu koja se može prodati ili iznajmiti. To znači da svaki novi stanar ili kupac imovine može procijeniti potrošnju energije zgrade. Certifikat daje dvije vrijednosti: primarnu i krajnju potrošnju energije. Primarna potrošnja energije ovisi o izolaciji zgrade i korištenom sistemu girjanja. Konačna potrošnja energije pokazuje koliko energije sistem grijanja zapravo koristi u ovoj kući. Od 1. januara 2016. njemački savezni pravilnik o uštedi energije odredio je da primarna potrošnja energije nove zgrade ne smije prelaziti 61,98 kWh/m$^2$ godišnje. Za zgrade sa sistemom grijanja na fosilna goriva to znači da se ovojnica mora mnogo više izolirati. Uz to, mora se uložiti u sistem za potporu solarno-toplotnom grijanju. U usporedbu s ovim, zbog poboljšanog faktora primarne energije od 1,8 (prethodno 2,4), u zgradama s toplotnom pumpom ne moraju se provoditi dodatne mjere energetske učinkovitosti, čak i prema najnovijoj verziji njemačke savezne uredbe o uštedi energije.

U referentnoj zgradi njemačke savezne uredbe o uštedi energije nove zgrade s toplotnom pumpom zrak-voda postižu energetski razred A, a toplotna pumpa voda-voda ide sve do A+. U postojećim zgradama upotreba toplotnih pumpi može poboljšati razred energetske učinkovitosti do 6 klasa. Prema procjeni Evropske komisije, 40 % stambenih zgrada i 65 % poslovnih zgrada Evropskoj uniji bi trebalo da se do 2030. godine zagrijava strujom. U Evropskoj asocijaciji proizvođača toplotnih pumpi (EHPA) očekuju da će to značiti da se u sljedećih deset godina učetverostući broj ovih pumpi. Podaci EHPA-e kazuju da se širom Unije koristi 13,3 miliona pumpi te da će se taj broj do 2030. povećati na 50 miliona.

Raspoloživost fosilnih goriva plina i nafte vremenski je ograničena pa ova činjenica sve više zaokuplja svijseti ljudi kao i potreba za zaptitom okoliša. Iz tog razloga korištenje obnovljivih izvora energije dobiva se više na značaju. S visokom oznakom energetske ocjene u cijelom rasponu, ovo je idealno čisto i zeleno inteligentsno rješenje grijanja.[19]

### 1.2 Prednosti korištenja toplotne pumpe

Najbitniji faktor za donešenje odluke ugradnje toplotne pumpe jeste 60 do 75 % niži relativni troškovi grijanja. Toplotne pumpe dobivaju ¾ potrebne energije (bez ikakvog dodatnog utroška goriva ili eketrične energije) iz okruženja u kojem živite. Zemlja, podzemna voda i vanjski zrak pohranjuju ogromne količine toplinske energije koje se pomoću toplotne pumpe mogu transformirati u energiju grijanja. Uštede su znatne u usporedbi s drugim konvencionalnim sistemima grijanja. Količina energije koju toplotna pumpa troši znatno je manja od količine proizvedene topline. Međutim, relativna ušteda ovisit će o tome da li trenutno

[19] https://issuu.com/ecos15/docs/ecos_news_88_web/s/17073794

koristite struju, ulje, propan ili prirodni plin i u relatnivnim troškovima različitih izvora energije u vašem području. Ako pokrenete toplotnu pumpu, trošit ćete manje plina ili nafte, ali više električne energije. Ako živite u području gdje je struja skupa, vaši operativni troškovi mogu biti veći. Ovisno o tim čimbenicima, rok povrata ulaganja u toplotnu pumpu zrak-voda, a ne u centralni klima uređaj, mogao bi biti od dvije do sedam godina.

Ako se danas odlučite instalirati dizalicu topline, trebali biste biti svjesni da ulažete u budućnost. Njihova prava vrijednost leži u mnogim mjerljivim i nemjerljivim aspektima. Osim sigurnosti ulaganja, fleksibilnosti, niskih troškova grijanja, udobnosti i mnogih ekonomskih i ekoloških prednosti, toplotna pumpa je zapravo ulaganje u vašu budućnost i budućnost vaše djece.

Toplotna pumpa idealno je rješenje za grijanje i hlađenje novoizgrađenih ili obnovljenih zgrada ili za zamjenu postojećeg sistema grijanja. Budući da djeluje na principima niskotemperaturnog grijanja, pogodna je za podno grijanje i grijanje pomoću zidnih radijatora, kao i kombinaciju oba. Toplotne pumpe posebno su prikladne za grijanjem radijatora, jer novi modeli za visoke temperature mogu doseći temperaturu vode do 80$^{o}$C.

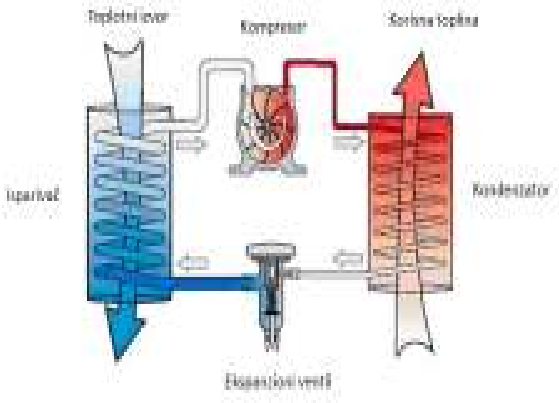
Jedinstvena tehnologija toplotne pumpe omogućava vašem sistemu grijanja da zagrijava vaš dom tokom zime i hladi ga tokom ljeta bez dodatnih radova ili ulaganja. Sistem toplotne pumpe može se koristiti za hlađenje bez obzira koirstite li ventilatore ili podno grijanje.

Sistem toplotne pumpe nije samo vrlo učinskovit, ujedno je i jedan od natiših dostupnih na tržištu. Ovaj obnovljivi sistem grijanja je diskretan i vrlo tih, nudeći fleksibilnost na mjestu gdje ga možete postaviti i čineći ga savršenim za gotovo sve lokacije.

### 1.3 Princip rada toplotne pumpe

Toplotne pumpe prenose toplinu tako što cirkuliraju gas koji se naziva rashladno sredstvo kroz ciklus isparivanje i kondenzacije. Kompresor pumpa rashladno sredstvo između dva svitka izmjenjivača topline. U jednoj zavojnici rashladno sredstvo isparava pri niskom tlaku i apsorbira toplinu iz svoje okoline. Zatim se rashladno sredstvo komprimira na drugoj zavojnici, gdje se kondenzira pod visokim tlakom. U ovom se trenutku oslobađa toplina koju je apsorbiralo ranije u ciklusu. Rashladni siste toplotne pumpe sastoji se od kompresora i dvije zavojnice od bakrenih cijevi (jedna u aztvorenom i jedna izvana), okružene tankim aluminijskim rebrima za pomoć prijenosu topline. U načinu grijanja, tekuće rashladno sredstvo u vanjskim zavojnicama izvlači toplinu iz zraka i isparava u plin. Unutarnje zavojnice oslobađaju toplinu iz rashladnog sredstva dok se ona kondenzira natrag u tekućinu. Povratni ventil, u blizini kompresora, može promijeniti smjer protoka rashladnog sredstva radi hlađenja, kao i za odmrzavanje vanjskih zavojnica zimi. Sam proces odvija se u 4 faze gdje je rashladno sredstvo na početku prve faze hladna tekućina niskog pritiska. Rashladno sredstvo prelazi u isparivač i toplinska energija iz vanjskog zraka prolazi preko isparivača. To uzrokuje povećanje pritiska rashladnog sredstva i promjenu u toplu paru. Topla para tada ulazi u kompresor gdje joj se pomoću kompresije povećava temperatura i to rezultira njenim pretvaranjem u vrući plin. Vrući plin se tada kondenzira prelaskom preko jedne strane izmjenjivača topline. Toplina se prenosi na hladniju stranu (strana gdje se nalazi voda) izmjenjivača topine i tada se kroz sistem prenosi do spremjika tople vode. Kako se temperatura rashladnog sredstva smanjuje,

stanje se mijenja iz vrućeg plina natrag u hladnu paru. Unatoč padu temperature, hladna para i dalje zdržava visoki pritisak i kako bi se pritisak smanjio para prolazi kroz ekspanzijski ventil. To uzrokuje pad pritiska i temperatura se znatno nižava, vraćajući rashladno sredstvo u prvobitno stanje hladne tekućine niskog pritiska. Kroz ovaj ciklus prolazi samo rahladno sredstvo, a voda se zagrijava dok putuje kroz izmjenjivač topline. Toplinska energija rashladnog sredstva prolaskom kroz izmjenjivač topline predaje se vodi kojoj tada raste temperatura. Ova zagrijanja voda ulazi u krug grijanja zgrade, a može se koristiti i za dobivanje sanitarne tople vode putem spremnika tople vode. Energetska učinskovistos koja se postiže ovim procesom iznino je visoka, te na primjer pri vanjskoj temperaturi od +7ºC COP (Coefficient of Performance) može iznositi 4.00, odnosno sistem za svaki kW električne energije koji utroši daje čak 4.00 kW toplinske energije. Naravno, s padom vanjske temperature, pada i učinkovitost sistema, no istovremeno raste s porastom vanjske temperature.



## 1.4 Izvori topline za toplotne pumpe

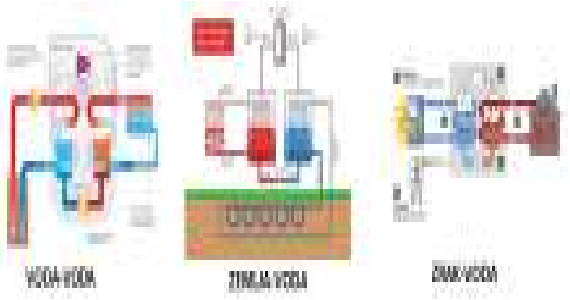
Kako bi se maksimalno iskoristili svi izvori koje nam okoliš pruža, tako toplotne pumpe mogu crpiti energiju iz zemlje, vode i zraka.

Toplina zemlje je najsigurniji izvor topline za toplotnu pumpu. Razlog tome je činjenica da tlo ima konstantnu temperaturu tijekom cijele godine koja varira između 8oC i 12oC. Dakle, tlo je zimi mnogo toplije od vanjskog zraka i ta se toplinska energija uspješno koristi za zagrivanje prostora. Postoje dva načina na koja se toplina preuzima iz zemlje: putem podzemnog kolektora i dubinskom sondom. Podzemni kolektor se postavlja na određenu dubinu ispod dubine smrzavanja tla. Takav se sistem može temljiti na vodi i na plinu, a princip rada im je jednak. Voda ili plin (ovisno o sistemu koji se koirsti) će cirkulisati cijevima i kad njihova temperatura dosegne željenu razinu, cirkuliraju cijevima u prostoru koji se želi zagrijati. Dubinska sonda se postavlja u obliku U-cijevi, a kroz njunajčešće struji voda. One se koriste na onim područjima i kojima zbog površine ili loše zemlje nije moguće postaviti podzemne kolektore.[20] Ukopavaju se na dubine od 100 do 200 metara, osim ako zbog terena to nije moguće pa se postavljaju na dubine koje više odgovaraju takvom terenu. Dubinske sonde najbolje čuvaju jednakost temperature jer zbog dubine na koju su ukopane na njih ne utječe kimatska promjena.

Kod sistema koji koirsti vodu kao primarni izvor topline koirste se dvije buštine na razmaku od minimalno 15 metara. Iz jedne se vrpi voda temperature oko 10ºC, a kroz drugu cijev se voda vodi natrag do izvora. U takvom se sistemu kao ozvor energije koirsti toplina jezera, rijeka, mora ili otpadnih voda nekih industrija.

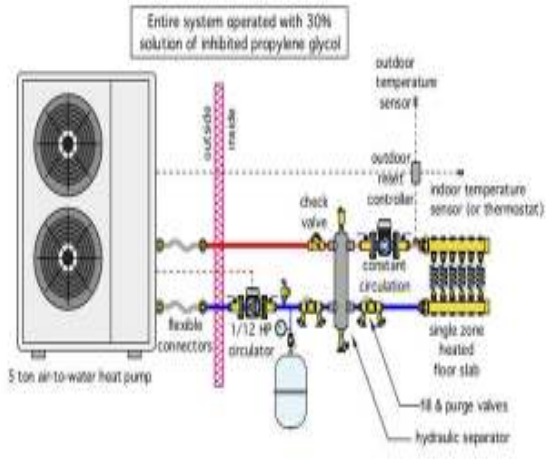
[20] https://issuu.com/ecos15/docs/ecos_news_80_web/s/12570649

Zrak se kao izvor toplinske energije najčešće koristi kod zagrijavnja kućanstva, a vrsta toplotne pumpe koja se u ovakvom sistemu koristi zove se inverterska klima. Ona se sastoji od vanjske i unutarnje jedinice koje mogu imati dvije funkcije: u slučaju hlađenja imaju funkciju kondenzatra, a u slučaju grijanja imaju funkciju isparivača. Inverteska klima uređaj predstavlja najekonomičniju soluciju za grijanje klima uređajem, a djeluje tako da prilikom zagrijavanja prstora radi maksimalnom snagom dokle god je potrebno da postigne željenu temperaturu. Kada je postigne, snaga rada se smanjuje i toplina se održava.

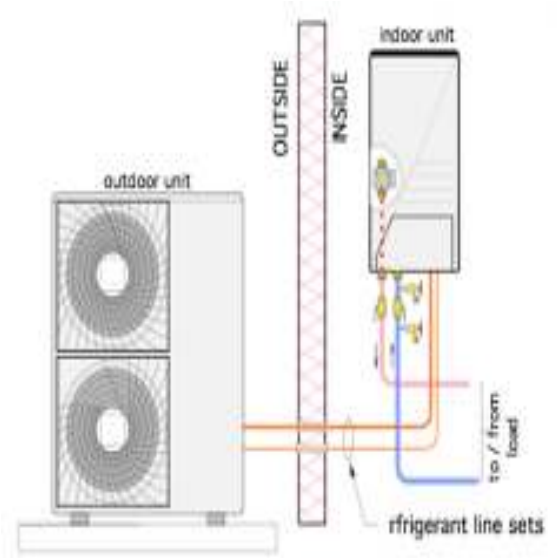


## 1.5 Izvedbe toplotne pumpe

Toplotne pumpe su dostupne u monoblock i split izvedbi. Kod monoblock izvedbe je brža i jednostavnija ugradnja u jednom danu. Može se instalirati na pod, zid ili krov. Priključak na električnu mrežu se nudi u monofaznim i trofaznim izvedbama. Zahvaljujući DC Inverter „brushless“ ventilatorima, toplotne pumpe rade sa vrlo niskom razinom buke. Osim radom radom svih komponenti toplotne pumpe, regulacija upravlja sa cirkulacionom pumpom kruga grijanja i preklopnim troputim ventilom. Funkcija kaskadnog upravljanja daje mogućnost više toplotnih pumpi u kaskadu, a i zbog instaliranja veće snage i upravljanja sa jednog mjesta.




Split izvedba – toplotna pumpa se sastoji od vanjske i unutarnje jedinice. U unutarnjoj jedinici su ugrađeni cirkulaciona pumpa, elektro grijač i ekspanziona posuda. Dvostepeni rotacioni kompresor sa poboljšanom tehnologijom ubrizgavanja, radi stabilno na temperaturama do -25ºC. Radi uštede energije, automatski prebacuje u način rada s nižom frekvenciojom kada temperatura dosegne zadanu vrijednost.



### 1.6 Planiranje, odabir i projektovanje sistema

Svako planiranje i projektiranje ima svoje početne korake i iako istina je da neke od njih možemo barem djelomično izvesti sami, ovisno o stručnosti i iskustvu naravno, preporuka je da se obratite stručnom projektantu/firmi koja će vam izraditi potpunu dokumentaciju i predložiti moguća rješenja sistema. Naravno, to će povisiti početnu investiciju, ali zasigurno ne onoliko koliko bi koštali naknadni popravci ili zamjene u slučaju krivog odabira ili izvođenja. Pokazalo se u praksi da izbjegavanje ovog koraka često rezultira nezadovoljstvom korisnika, gubitkom vremena i uloženog novca. Prije samog ugovaranja izvođenja informirajte se o sljedećim faktorima kako biste isplanirali budžet u skladu s konkretnim željama/potrebama izvedbe:

- energetske potrebe – potrebno je izraditi proračun fizike objekta i saznati njegove energetske potrebe koje ovise o željenim trošilima, površini i izolaciji objekta;
- kapacitet – sukladno energetskim potrebama objekta radi se odabir kapaciteta toplotne pumpe. Vrijednosti se pretežno kreću u rangu od 3.6 do 16.0 kW ili prevedeno za veličine objekta od 40 do 400 $m^2$;
- funkcionalnost – bitno je naglasiti sve željene funkcionalnosti (grijanje + potrošna topla voda, samo potrošna topla voda, grijanje + hlađenje + potrošna topla voda);
- kontrola – uz standaradnu kontrolu pomoću žičnih ugradbenih termostata moguća je i daljinska kontrola sa drugih lokacija putem internetske veze;
- namjena – kratak opis namjene objekta (stambeni, turistički, poslovni).

Kako je riječ o obnovljivom izvoru energije visoke efikasnosti, realno je da je početna investicija nešto veća u odnosu na klašične sisteme grijanja. S druge strane, investitorima je u startu osigurana ušteda pošto im je potreban tek priključak električne energije i nije potrebno raditi dimnjak. Cijena toplotne pumpe je u startu veća od konkurentskih rješenja, ali je povrat investicije jednako veći kroz manje prosječne operativne troškove. Kako biste bili sigurni da je dizalica topline pravo rješenje za vas, ukratko ćemo navesti prednosti i nedostatke takvog sistema.

**Prednosti:**

- korištenje prirodnih, neiscrpnih izvora energije, neovisnosti o energentima,
- nema štetnih emisija,
- učinkovitost: do 75 % energije dolazi iz okoliša. Samo 25 % treba dodati u obliku električne struje,
- hlađenje tokom ljetnih mjeseci,
- jednostavna thenologija visokih vrijednosti, niskih troškova održavanja s dugim vijekom trajanja.

**Nedostaci:**

- veća početna ulaganja,
- potreban je niskotemperaturni režim grijanja, što zahtijeva preinake u slučaju prelaska s visokotemperaturnog režima.

## ZAKLJUČAK

Toplotne pumpe su vrsta HVAC (grijanje, ventilacija i klimatizacija) sistema koji koriste električnu energiju za prijenos topline s jedne lokacije na drugu. Oni su visoko efikasan način za grijanje i hlađenje zgrada, jer mogu prenijeti toplinu umjesto da je stvaraju, što rezultira manjom potrošnjom energije i uštedom troškova. Osim toga, toplotne pumpe se mogu koristiti i za druge primjene kao što su grijanje vode i grijanje bazena. Također se smatraju ekološki prihvatljivijim u poređenju sa tradicionalnim HVAC sistemima jer emituju manje gasova staklene bašte. Međutim, oni možda neće biti

tako efikasni u ekstremno hladnim klimama i mogu zahtijevati dodatne izvore grijanja.

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# 1 HEAT PUMPS

A heat pump is an electrical device that extracts heat from one place and transfers it to another. It is not a new technology, it has been used all over the world for decades, and refrigerators and air conditioners are the most famous examples.[21]

Refrigerators and air conditioners are both examples of heat pumps that operate specifically in cooling mode. A refrigerator is basically an insulated box with an attached heat pump system where the evaporator coil is located inside the box, usually in the freezer compartment. Heat is absorbed from this location and transferred to the outside, usually behind or below the unit that houses the condenser coil. Similarly, an air conditioner transfers heat from the house to the outside.

Heat pumps are devices that use the heat contained in the air to heat the hot water used for heating and domestic hot water in your facility. They have a high energy efficiency, which is why they belong to renewable energy sources and, as a rule, provide a COP higher than 4. In this case, the heat pump can produce 4 kW of thermal energy for every kW of electricity consumed.

It is interesting that even at temperatures below 0oC, the heat pump can extract heat from the surrounding air, thanks to modern inverter compressors, the operating mode extends up to -28oC (thanks, for example, to compressors with flow-injection technology), which ensures the functioning of the system regardless to the position of the object and the outside temperature. Since the ground and the air outside always contain some heat, a heat pump can bring heat into the house even on cold winter days. In fact, air at -18oC contains about 85 percent of the heat it contained at 21oC. The heat pump cycle is fully reversible, so it can provide year-round climate control for your home. In addition to heating, the heat pump can also cool the space, if consumers that can cool the space are installed (floor/wall/ceiling heating or fan coils).

It achieves the highest efficiency on buildings (new) with a high degree of thermal insulation. In doing so, it is suggested to use inert heating systems (floor, ceiling, wall), which require lower temperatures that mean[22] less load on the outdoor unit and less power consumption.

Although the heat pump is primarily used in heating systems, in versions where the heat is removed by water, it can also be used for the preparation of domestic hot water (DHW). These are usually devices with a smaller nominal power of 2 to 12 KW and a drive power of 0.6 to 5.2 kW, and in this way it is possible to reduce the energy consumption for the preparation of PTV by 2/3.
When we are preparing for new investments, replacement of the old or for the needs of a new heating system, we must ask ourselves what are the advantages and long-term profitability of that decision. Does the price of the heat pump justify the investment for

[21] https://issuu.com/ecos15/docs/ecos_news_88_web/s/17073794

[22] https://issuu.com/ecos15/docs/ecos_news_88_web/s/17073794

further savings? Is it better to invest now and avoid replacing again when legal changes force us to do so? How much time is realistically left until major changes in energy prices? These are all real questions and are no longer just hypothetical.

### 1.1 Heat pump use in the world

Air source heat pumps are one of the most efficient heating systems available to homeowners and businesses. For a reason, for example, in Switzerland every third new building is equipped with some type of heat pump, in Sweden 7 out of 10 new buildings, and in Germany and Iceland one quarter. In many countries, new laws are being sought or are already being passed, according to which gas connections on new constructions will be waived in the near future. In Germany, an energy certificate must be available for every building that can be sold or rented. This means that any new tenant or property buyer can estimate the building's energy consumption. The certificate gives two values: primary and final energy consumption. The primary energy consumption depends on the insulation of the building and the heating system used. The final energy consumption shows how much energy the heating system actually uses in this house. As of January 1, 2016, the German Federal Energy Saving Ordinance stipulated that the primary energy consumption of a new building must not exceed 61.98 kWh/m2 per year. For buildings with a fossil fuel heating system, this means that the envelope has to be insulated much more. In addition, it must be invested in a system to support solar thermal heating. Compared to this, due to the improved primary energy factor of 1.8 (previously 2.4), no additional energy efficiency measures need to be implemented in heat pump buildings, even according to the latest version of the German Federal Energy Saving Ordinance. In the reference building of the German federal energy saving regulations, new buildings with air-to-water heat pumps achieve energy class A, and water-to-water heat pumps go all the way to A+. In existing buildings, the use of heat pumps can improve the energy efficiency class up to 6 classes. According to the estimate of the European Commission, 40% of residential buildings and 65% of commercial buildings in the European Union should be heated by electricity by 2030.

The European Heat Pump Manufacturers Association (EHPA) expects that this will mean that the number of these pumps will quadruple in the next ten years. EHPA data show that 13.3 million pumps are used across the Union and that number will increase to 50 million by 2030. The European Heat Pump Manufacturers Association (EHPA) expects that this will mean that the number of these pumps will quadruple in the next ten years. EHPA data show that 13.3 million pumps are used across the Union and that number will increase to 50 million by 2030. The European Heat Pump Manufacturers Association (EHPA) expects that this will mean that the number of these pumps will quadruple in the next ten years. EHPA data show that 13.3 million pumps are used across the Union and that number will increase to 50 million by 2030.

The availability of fossil fuels, gas and oil is limited in time, so this fact is increasingly preoccupying the minds of people, as well as the need to protect the environment. For this reason, the use of renewable energy sources is gaining more importance. With a high energy rating across the range, this is the ideal clean and green intelligent heating solution.[23]

[23] https://issuu.com/ecos15/docs/ecos_news_88_web/s/17073794

## 1.2 Advantages of using a heat pump

The most important factor for making the decision to install a heat pump is 60 to 75% lower relative heating costs. Heat pumps get ¾ of the required energy (without any additional consumption of fuel or electricity) from the environment in which you live. The earth, underground water and outside air store huge amounts of thermal energy that can be transformed into heating energy using a heat pump. The savings are considerable compared to other conventional heating systems. The amount of energy consumed by the heat pump is significantly less than the amount of heat produced. However, the relative savings will depend on whether you currently use electricity, oil, propane, or natural gas and the relative costs of different energy sources in your area. If you run a heat pump, you will use less gas or oil, but more electricity. If you live in an area where electricity is expensive, your operating costs may be higher. Depending on these factors, the return on investment in an air-to-water heat pump, rather than a central air conditioner, could be from two to seven years.

If you decide to install a heat pump today, you should be aware that you are investing in the future. Their true value lies in many measurable and immeasurable aspects. In addition to investment security, flexibility, low heating costs, comfort and many economic and environmental advantages, a heat pump is actually an investment in your future and the future of your children.

The heat pump is the ideal solution for heating and cooling newly built or renovated buildings or for replacing an existing heating system. Since it works on the principles of low-temperature heating, it is suitable for underfloor heating and heating with wall radiators, as well as a combination of both. Heat pumps are especially suitable for heating radiators, because new models for high temperatures can reach water temperatures of up to 80oC.

The unique heat pump technology allows your heating system to heat your home in the winter and cool it in the summer without additional work or investment. A heat pump system can be used for cooling regardless of whether you use fans or underfloor heating.

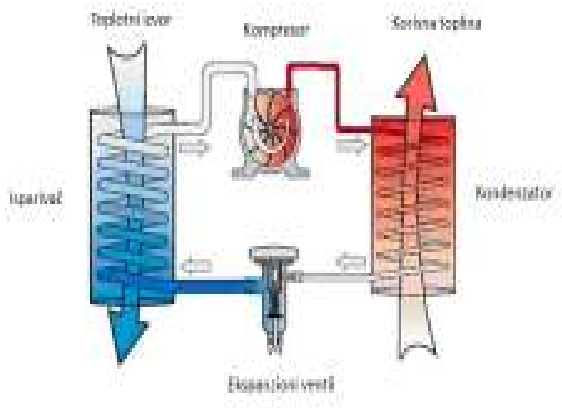
The heat pump system is not only very efficient, it is also one of the quietest available on the market. This renewable heating system is discreet and very quiet, offering flexibility in where you can place it and making it perfect for almost any location.

## 1.3 The principle of operation of the heat pump

Heat pumps transfer heat by circulating a gas called a refrigerant through a cycle of evaporation and condensation. The compressor pumps the refrigerant between the two coils of the heat exchanger. In one coil, the refrigerant evaporates at low pressure and absorbs heat from its surroundings. The refrigerant is then compressed on the second coil, where it condenses under high pressure. At this point, the heat it absorbed earlier in the cycle is released. A heat pump refrigeration system consists of a compressor and two coils of copper pipes (one inside and one outside), surrounded by thin aluminum fins to aid heat transfer. In heating mode, the liquid refrigerant in the external coils extracts heat from the air and evaporates it into a gas. The internal coils release heat from the refrigerant as it condenses back into liquid. A non-return valve, near the compressor, can change the direction of the refrigerant flow for cooling purposes, as well as for defrosting the outdoor coils in winter.

The process itself takes place in 4 stages, where the coolant at the beginning of the first stage is a cold, low-pressure liquid. The refrigerant passes into the evaporator and the thermal energy from the outside air passes through the evaporator. This causes the refrigerant pressure to increase and change to hot steam. The hot steam then enters the compressor, where its temperature increases with the help of compression, and this results in its transformation into a hot gas. The hot gas is then condensed by passing over one side of the heat exchanger. The heat is transferred to the cooler side (the side where the water is located) of the heat exchanger and is then transferred through the system to the hot water tank. As the temperature of the refrigerant decreases, the state changes from a hot gas back to a cold vapor. Despite the drop in temperature, the cold steam still maintains a high pressure, and in order to reduce the pressure, the steam passes through the expansion valve. This causes the pressure to drop and the temperature to drop significantly, returning the refrigerant to its original state of cold, low-pressure liquid.

Only the refrigerant passes through this cycle, and the water is heated as it travels through the heat exchanger. The thermal energy of the coolant passing through the heat exchanger is transferred to the water, which then increases in temperature. This heating water enters the heating circuit of the building, and it can also be used to obtain sanitary hot water through a hot water tank. The energy efficiency achieved by this process is extremely high, and for example, at an external temperature of +7oC, the COP (Coefficient of Performance) can be 4.00, that is, the system for every kW of electricity it consumes produces as much as 4.00 kW of thermal energy. Of course, as the outside temperature drops, the efficiency of the system also decreases, but at the same time it increases with the increase in outside temperature.



## 1.4 Heat sources for heat pumps

In order to make maximum use of all the sources that the environment provides us, heat pumps can draw energy from the earth, water and air.

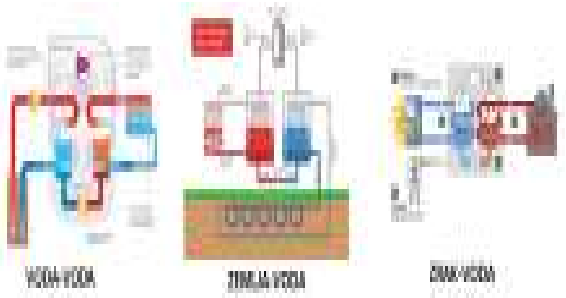
The heat of the ground is the safest source of heat for a heat pump. The reason for this is the fact that the soil has a constant temperature throughout the year, which varies between 8oC and 12oC. Therefore, the ground is much warmer than the outside air in winter and this thermal energy is successfully used to heat the space. There are two ways in which heat is taken from the ground: through an underground collector and through a deep probe. The underground collector is placed at a certain depth below the depth of soil freezing. Such a system can be based on water and gas, and the principle of operation is the same. Water or gas (depending on the system being used) will circulate through the pipes and when their temperature reaches the desired level, they circulate through the pipes in the space that is to be heated. The depth probe is placed in the form of a U-tube, and water usually flows through it.[24]collectors. They are dug to depths of 100 to 200 meters,

[24]https://issuu.com/ecos15/docs/ecos_news_80_web/s/12570649

unless this is not possible due to the terrain, so they are placed at depths that are more suitable for such terrain. Deep probes best preserve temperature equality because they are not affected by chemical change due to the depth at which they are buried.

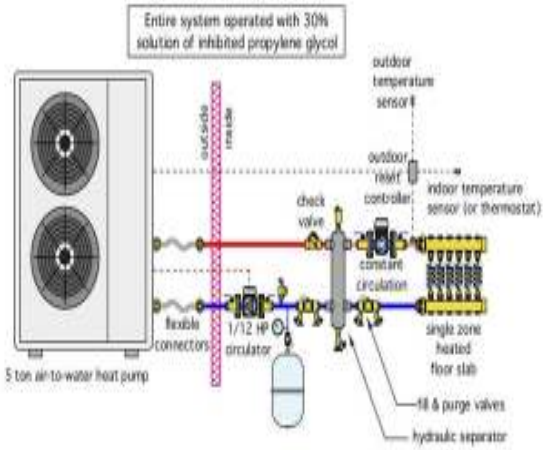
In the system that uses water as the primary source of heat, two wells are used at a distance of at least 15 meters. Water at a temperature of about 10oC is drawn from one, and the water is led back to the source through the other pipe. In such a system, the heat of lakes, rivers, seas or waste water of some industries is used as an energy source.

Air is most often used as a source of heat energy for household heating, and the type of heat pump used in such a system is called an inverter air conditioner. It consists of an external and an internal unit that can have two functions: in the case of cooling, they have the function of a condenser, and in the case of heating, they have the function of an evaporator. Inverteska air conditioner represents the most economical solution for heating with an air conditioner, and it works in such a way that when heating the floor, it works at maximum power for as long as it takes to reach the desired temperature. When it reaches it, the work power is reduced and the heat is maintained.

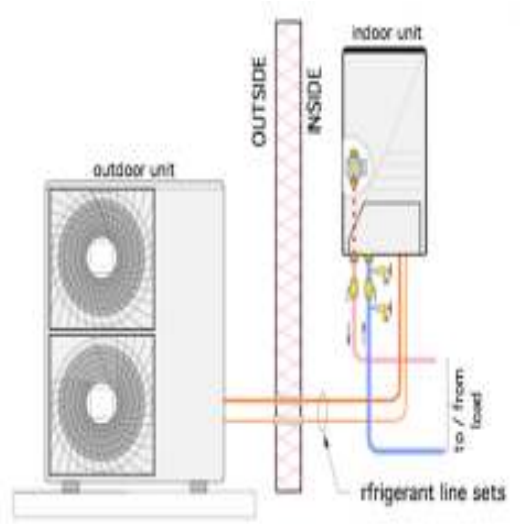


## 1.5 Performances of the heat pump

Heat pumps are available in monoblock and split versions.With the monoblock version, installation is faster and simpler in one day. It can be installed on the floor, wall or roof. Connection to the electrical network is offered in single-phase and three-phase versions. Thanks to the DC Inverter "brushless" fans, the heat pumps work with a very low noise level. In addition to the operation of all components of the heat pump, the regulation controls the circulation pump of the heating circuit and the switchable three-way valve. The function of cascade control gives the possibility of several heat pumps in a cascade, also due to the installation of higher power and control from one place.




Split design – the heat pump consists of an outdoor and an indoor unit. A circulation pump, an electric heater and an expansion tank are installed in the indoor unit. Two-stage rotary compressor with improved injection technology, works stably at temperatures down to -25oC. To save energy, it automatically switches to a lower frequency mode when the temperature reaches the set value.




## 1.6 Planning, selection and system design

Every planning and design has its initial steps and although it is true that some of them can be carried out at least partially by ourselves, depending on the expertise and experience of course, it is recommended that you contact a professional designer/company that will prepare complete documentation for you and suggest possible system solutions. Of course, this will increase the initial investment, but certainly not as much as the subsequent repairs or replacements would cost in case of wrong selection or execution. It has been shown in practice that avoiding this step often results in user dissatisfaction, loss of time and invested money.

Before contracting the performance itself, inform yourself about the following factors in order to plan the budget in accordance with the specific wishes/needs of the performance:

- energy needs - it is necessary to make a calculation of the object's physics and find out its energy needs, which depend on the desired consumption, surface area and insulation of the object;
- capacity - in accordance with the building's energy needs, the capacity of the heat pump is selected. The values are mostly in the range from 3.6 to 16.0 kW, or translated for object sizes from 40 to 400 m2;
- functionality - it is important to emphasize all desired functionalities (heating + domestic hot water, only domestic hot water, heating + cooling + domestic hot water);
- control - in addition to standard control using wired built-in thermostats, remote control from other locations via an Internet connection is also possible;
- purpose - a brief description of the object's purpose (residential, touristic, business).

As it is a renewable energy source of high efficiency, it is realistic that the initial investment is somewhat higher compared to classic heating systems. On the other hand, investors are guaranteed savings at the start, since they only need an electricity connection and there is no need to build a chimney. The price of the heat pump is initially higher than competing solutions, but the return on investment is equally higher through lower average operating costs.

In order to make sure that a heat pump is the right solution for you, we will briefly list the advantages and disadvantages of such a system.

**Advantages:**

- use of natural, inexhaustible sources of energy, independence from energy sources,
- no harmful emissions,
- efficiency: up to 75% of energy comes from the environment. Only 25% should be added in the form of electricity,
- cooling during the summer months
- simple, high-value, low-maintenance, long-life technology.

**Disadvantages:**

- higher initial investment
- a low-temperature heating mode is required, which requires modifications in case of switching from a high-temperature mode.

## CONCLUSION

Heat pumps are a type of HVAC (heating, ventilation and air conditioning) system that uses electricity to transfer heat from one location to another. They are a highly efficient way to heat and cool buildings, as they can transfer heat instead of generating it, resulting in lower energy consumption and cost savings. In addition, heat pumps can be used for other applications such as water heating and pool heating. They are also considered more environmentally friendly compared to traditional HVAC systems as they emit fewer greenhouse gases. However, they may not be as effective in extremely cold climates and may require additional heating sources.

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