

Renesansa upravljanja s toploto: od nevidnega moža do toplotnih superračunalnikov

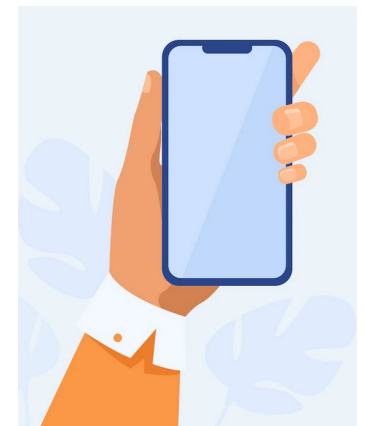
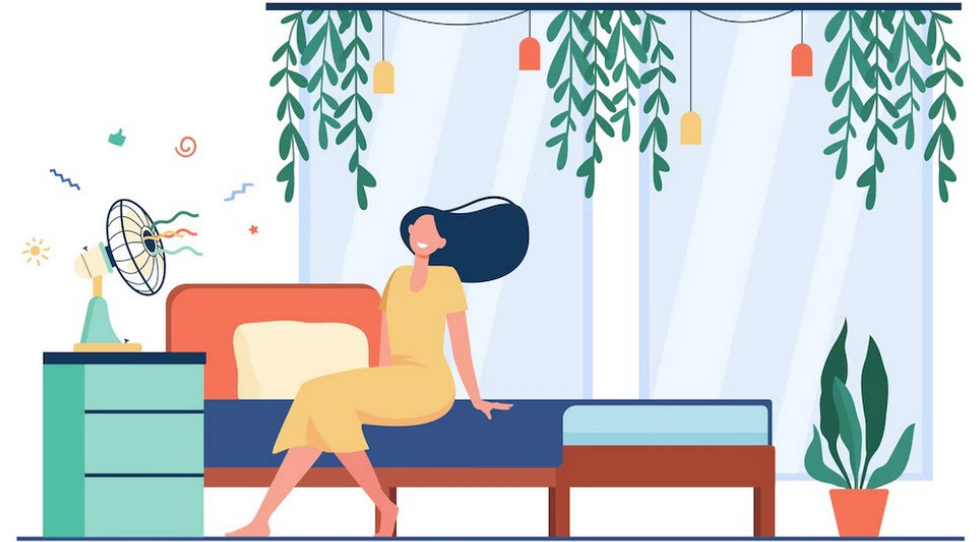
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katja.klinar@fs.uni-lj.si, katja.vozel@fs.uni-lj.si



Upravljanje s toploto

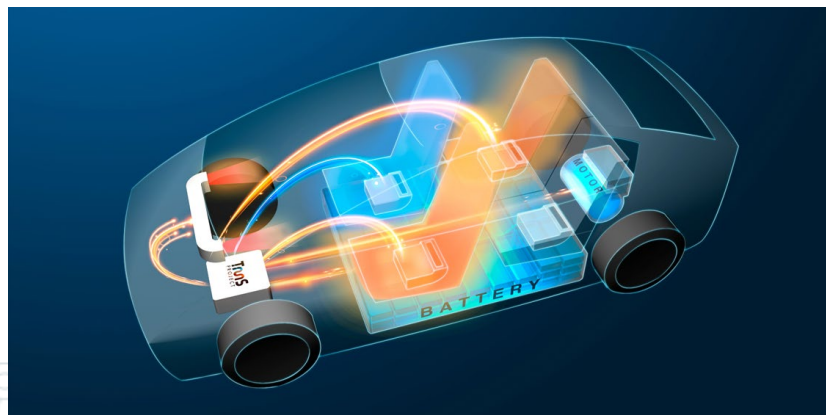
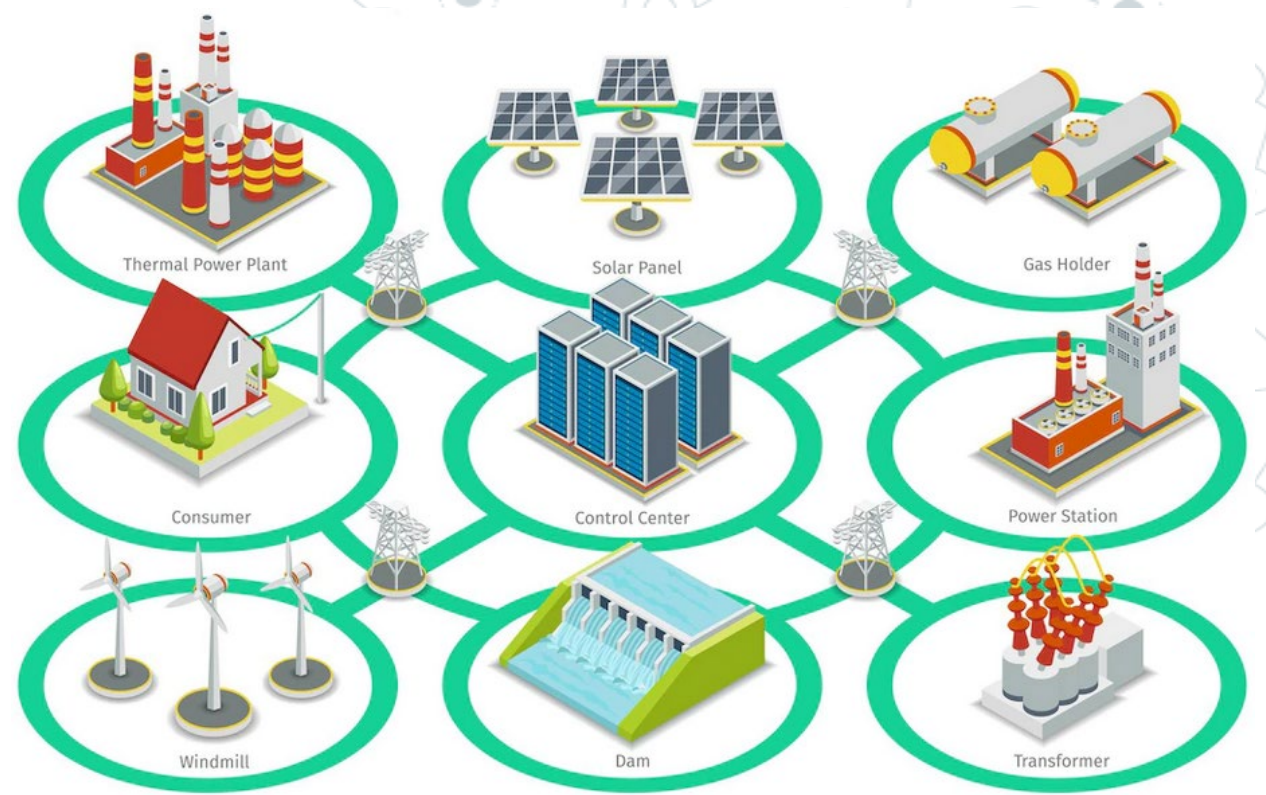
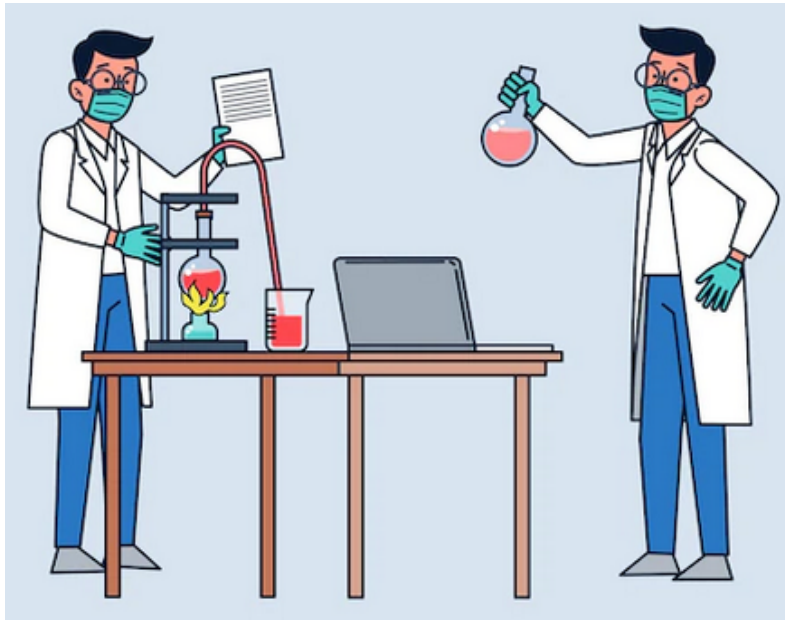
Skodelica znanosti, Ljubljana, 21.9.2022



University of Ljubljana
Faculty of *Mechanical Engineering*



Upravljanje s toploto



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Faculty of *Mechanical Engineering*



1.

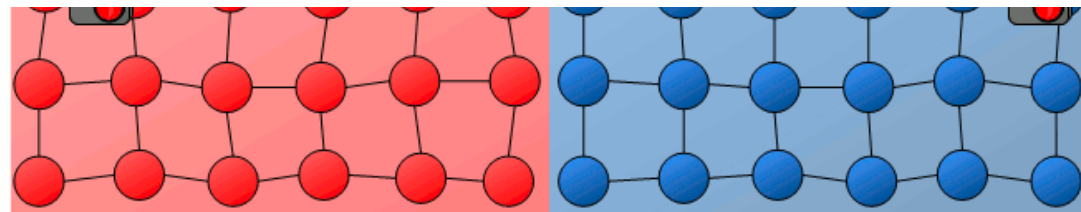
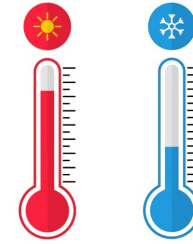
Kratek uvod v prenos toplote

Toplota, temperatura, prevod, prestop, sevanje

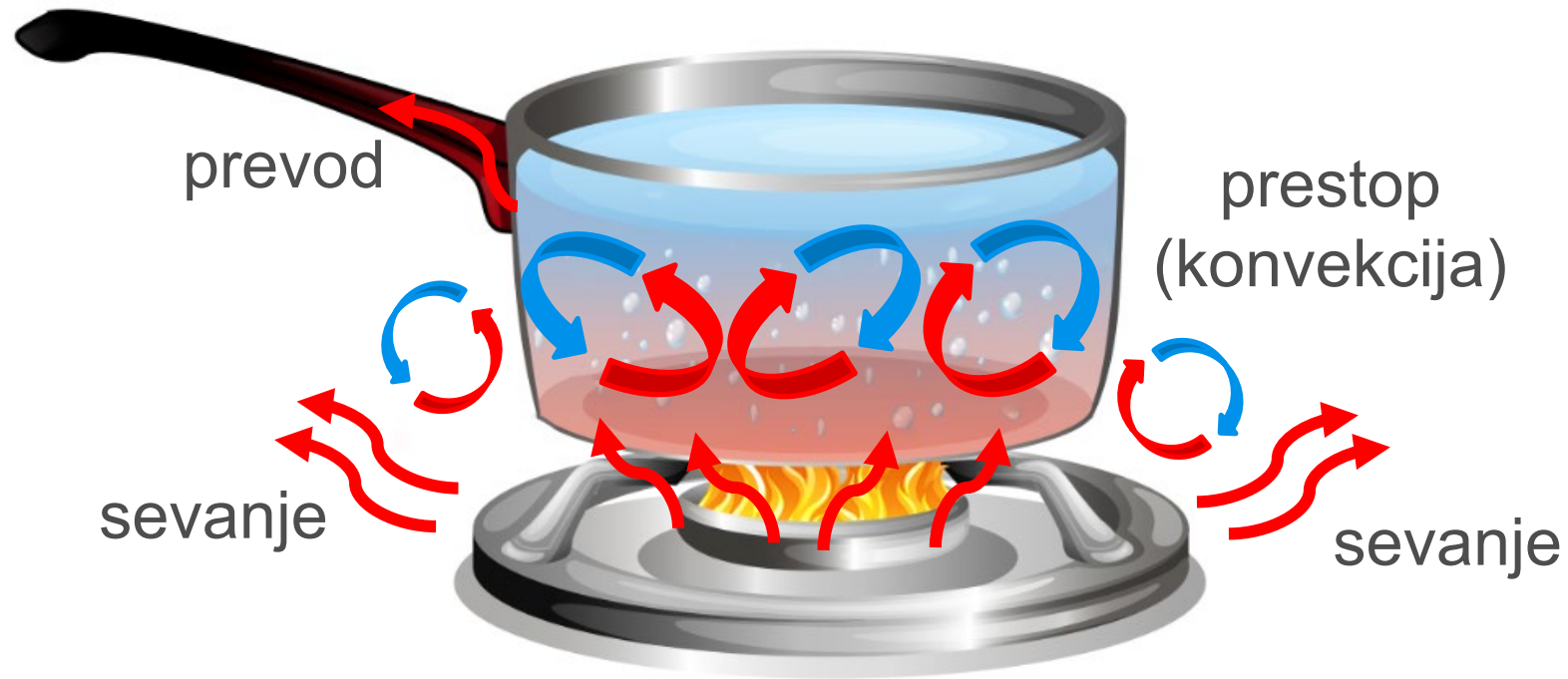


Osnovni pojmi

- ◎ toplota [J],
- ◎ toplotni tok [W],
- ◎ temperatura [°C, K].

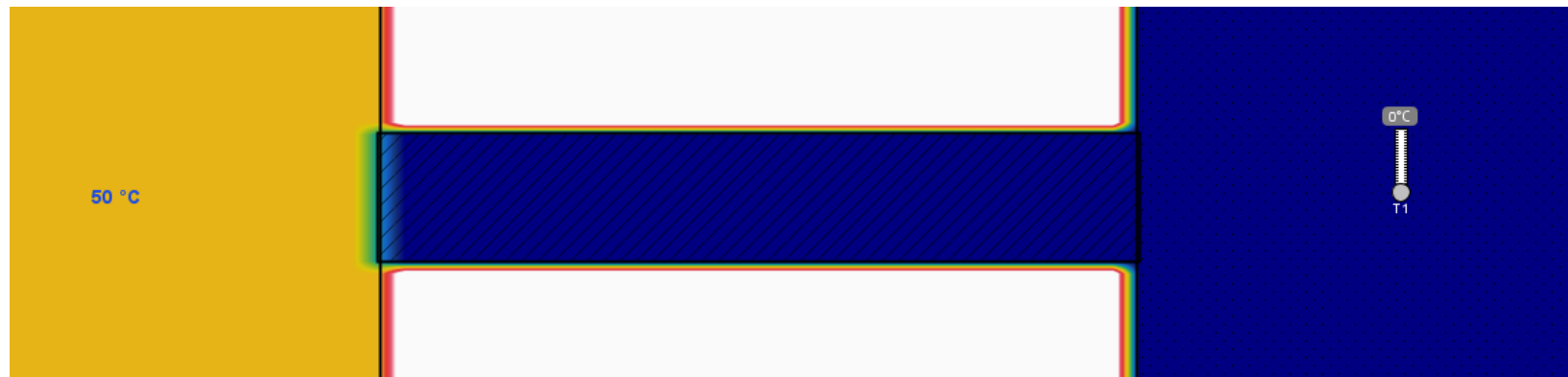


Prevod, prestop (konvekcija), sevanje



Toplotna prevodnost in termalna masa

- ◎ materiali z različno toplotno prevodnostjo:
 - toplotni izolatorji,
 - toplotni prevodniki.
- ◎ termalna masa je produkt gostote in specifične toplote.



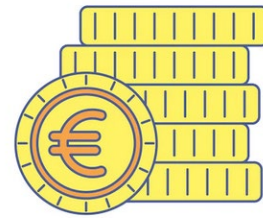
2.

Zakaj je upravljanje s toploto pomembno?

Evropski Zeleni dogovor, Pripravljeni na 55, Cilji trajnostnega razvoja



Vloga novih načinov upravljanja s toploto



4.

Uvod v toplotne kontrolne elemente

Analogija z elektronskimi elementi

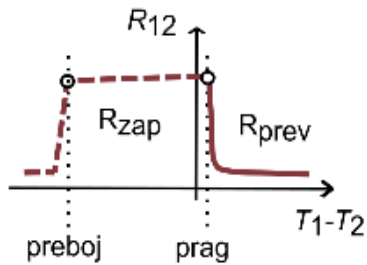


Toplotni upor

- predstavlja toplotno izolacijo;
- se uporablja za definicijo mehanizmov prenosa toplote;
- visoka in konstantna toplotna upornost;
- velika termalna masa.

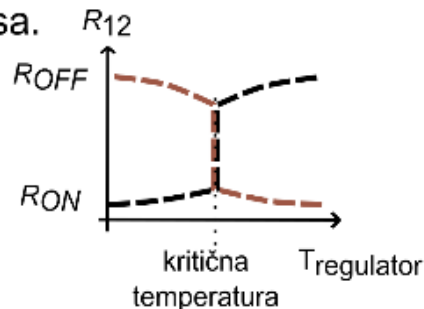
Toplotna dioda

- ojači toplotni tok;
- nizka toplotna upornost v prevodni smeri, visoka toplotna upornost v zaporni smeri;
- toplotno aktivirana;
- majhna termalna masa.



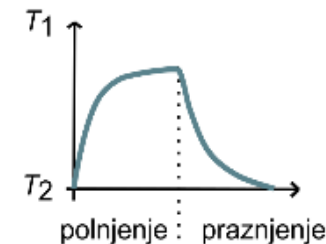
Toplotni regulator

- regulira toplotni tok;
- stanje z visoko ali nizko toplotno upornostjo je določeno s temperaturo,
- lahko ima fazni prehod;
- majhna termalna masa.



Toplotni kondenzator

- začasni hranilnik toplote;
- konstantne toplotne lastnosti;
- majhna termalna masa;
- majhna toplotna upornost.



Toplotni vodnik

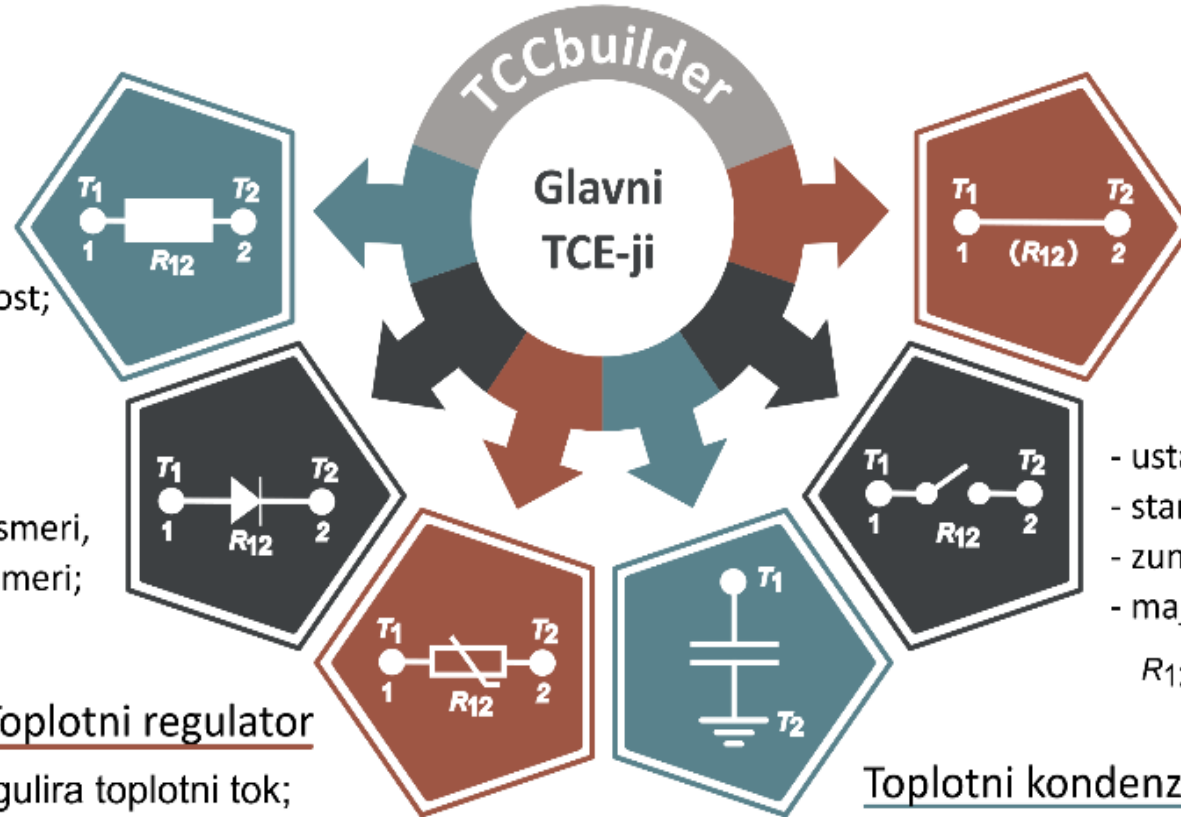
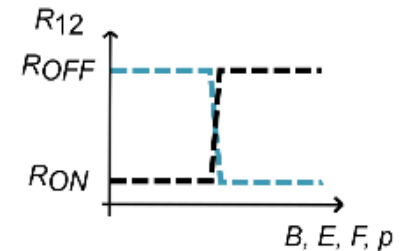
- vodi toplotni tok;
- nizka in konstantna toplotna upornost;
- majhna termalna masa.

$$R_{12} = \frac{\Delta T}{Q}$$

Toplotno stikalo

- ustavi ali prepušča toplotni tok;
- stanje z visoko in nizko toplotno upornostjo;
- zunanja aktivacija (E, B, F, p);
- majhna termalna masa.

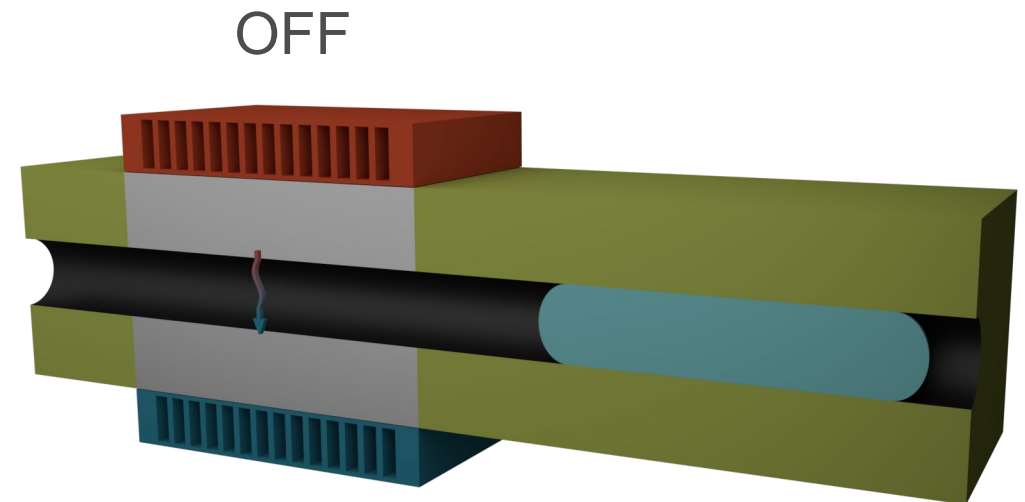
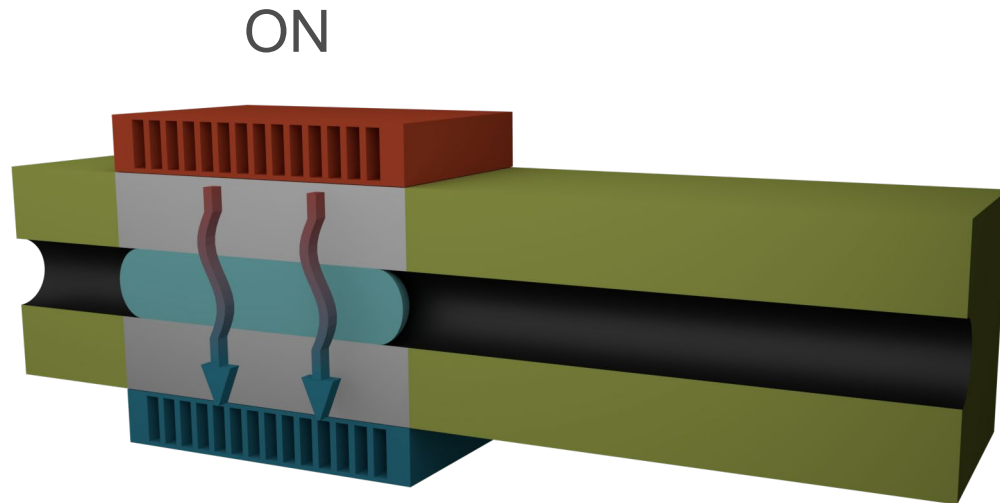
$$R_{12} = \frac{\Delta T}{Q}$$



Toplotno stikalo

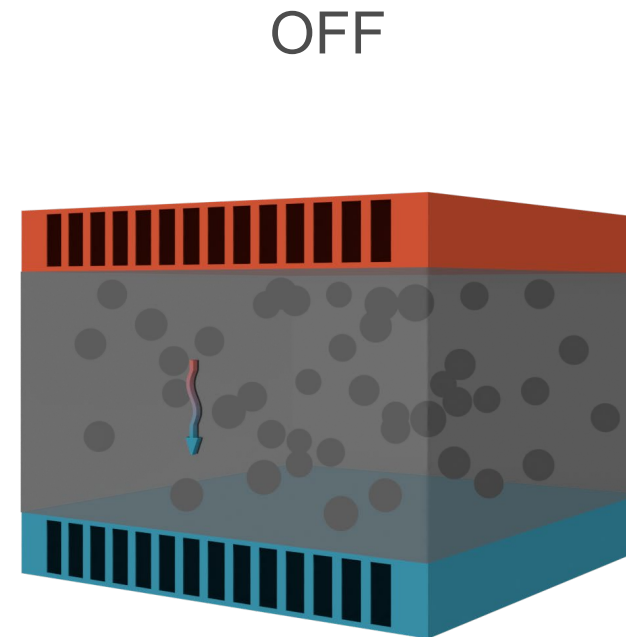
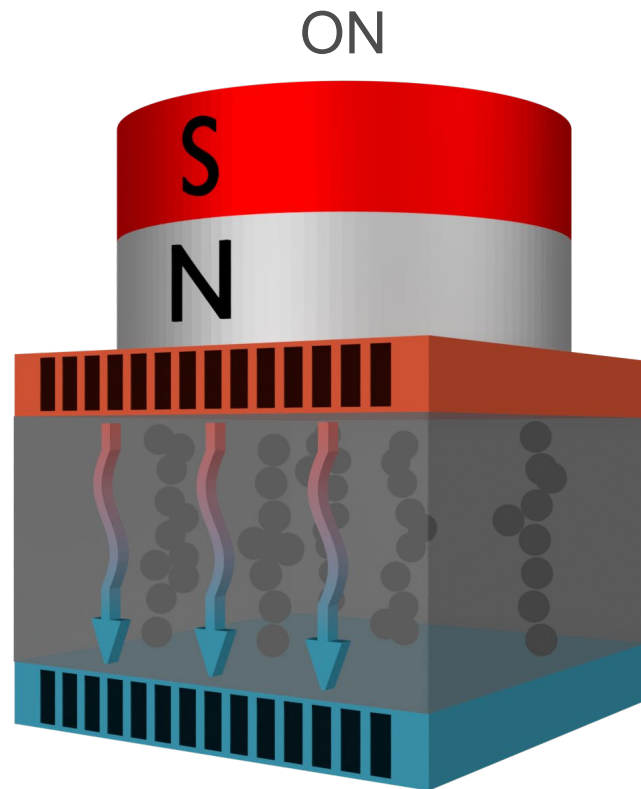
- ⦿ stanje ON: kot toplotni prevodnik,
- ⦿ stanje OFF: kot toplotni izolator.

- ⦿ Sprememba stanja ON/OFF je lahko fizičen premik



Toplotno stikalo

- © ali pa sprememba lastnosti materiala zaradi spremembe magnetnega polja, električnega polja, sile, tlaka.



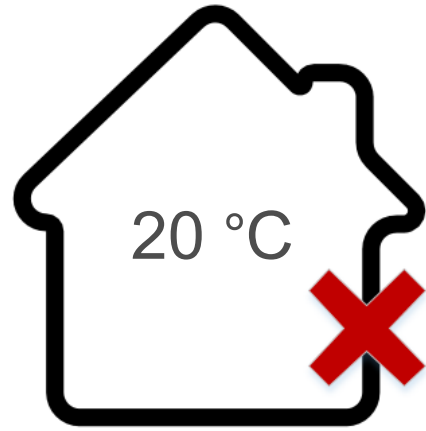
5.

Uporaba toplotnih kontrolnih elementov

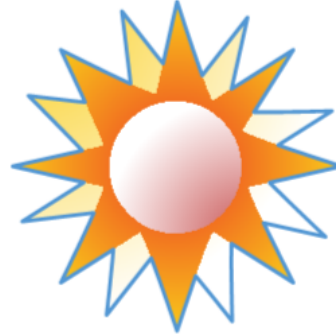
Regulacija temperature v bivalnem prostoru, nevidni mož



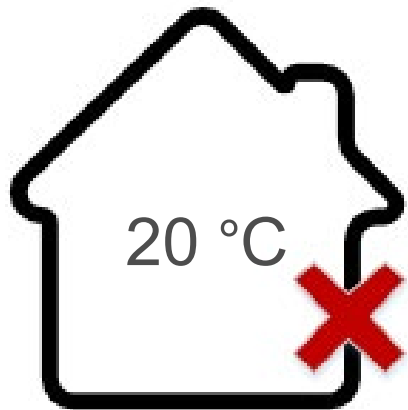
Hiša z običajno izolacijo



30 °C



Izolacija delno preprečuje
segrevanje notranjosti



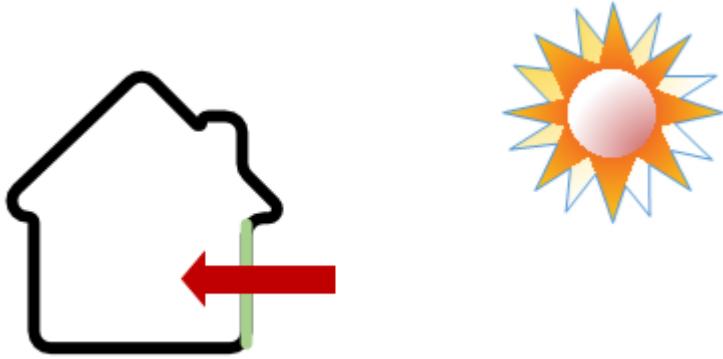
0 °C



Izolacija delno preprečuje
ohlajanje notranjosti



Hiša z izolacijo iz toplotnega stikala



Sončen zimski dan, stikalo omogoča prenos toplote iz ogrete stene v notranjost.

Nižja raba energije za ogrevanje (nižji stroški)



Oblačen zimski dan, stikalo prekine prenos toplote iz hladne stene v notranjost.



Hladna polenta noč, stikalo omogoča prenos toplote iz segrete notranjosti v okolico.

Nižja raba energije za hlajenje (nižji stroški)



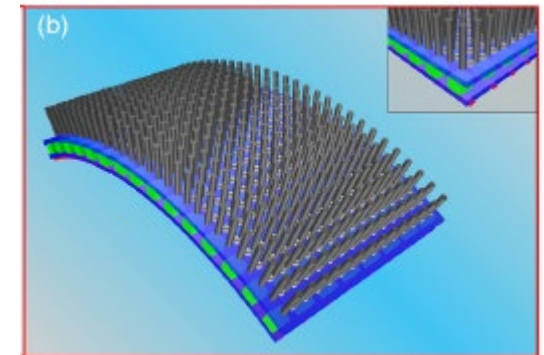
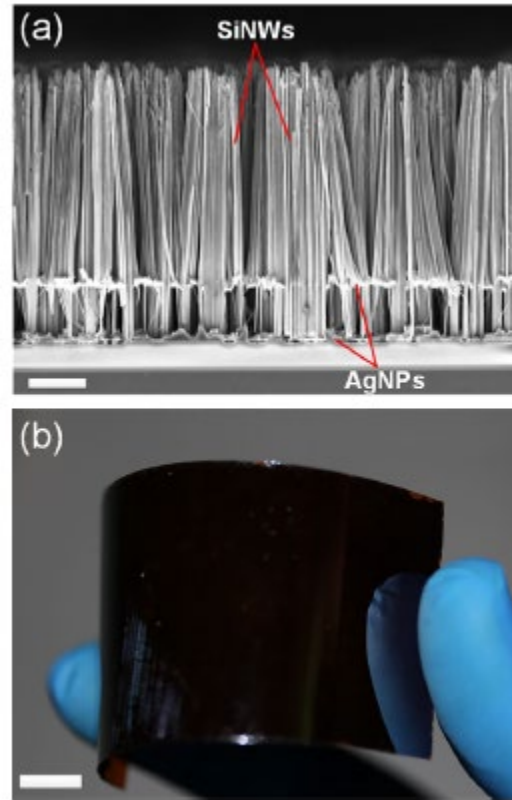
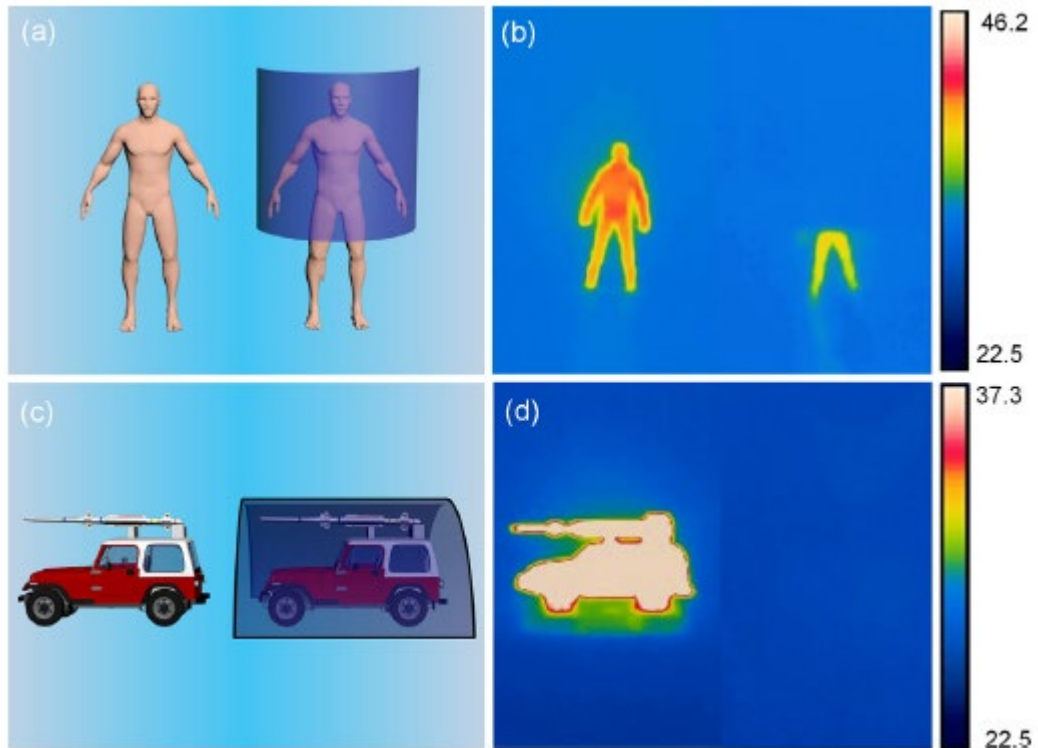
Vroč poletna noč, stikalo prekine prenos toplote iz ogrete stene v notranjost.



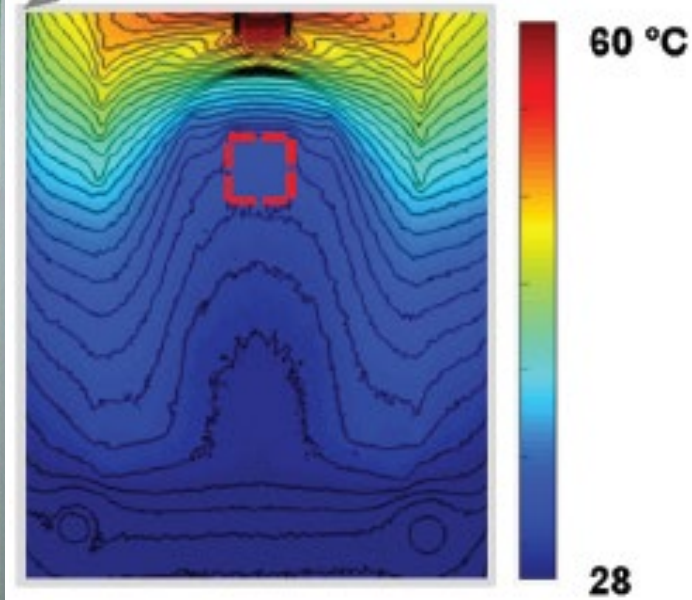
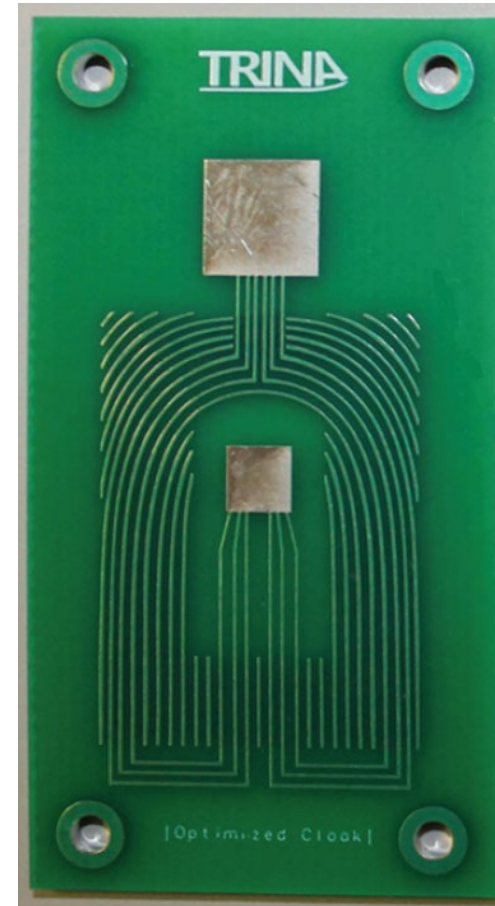
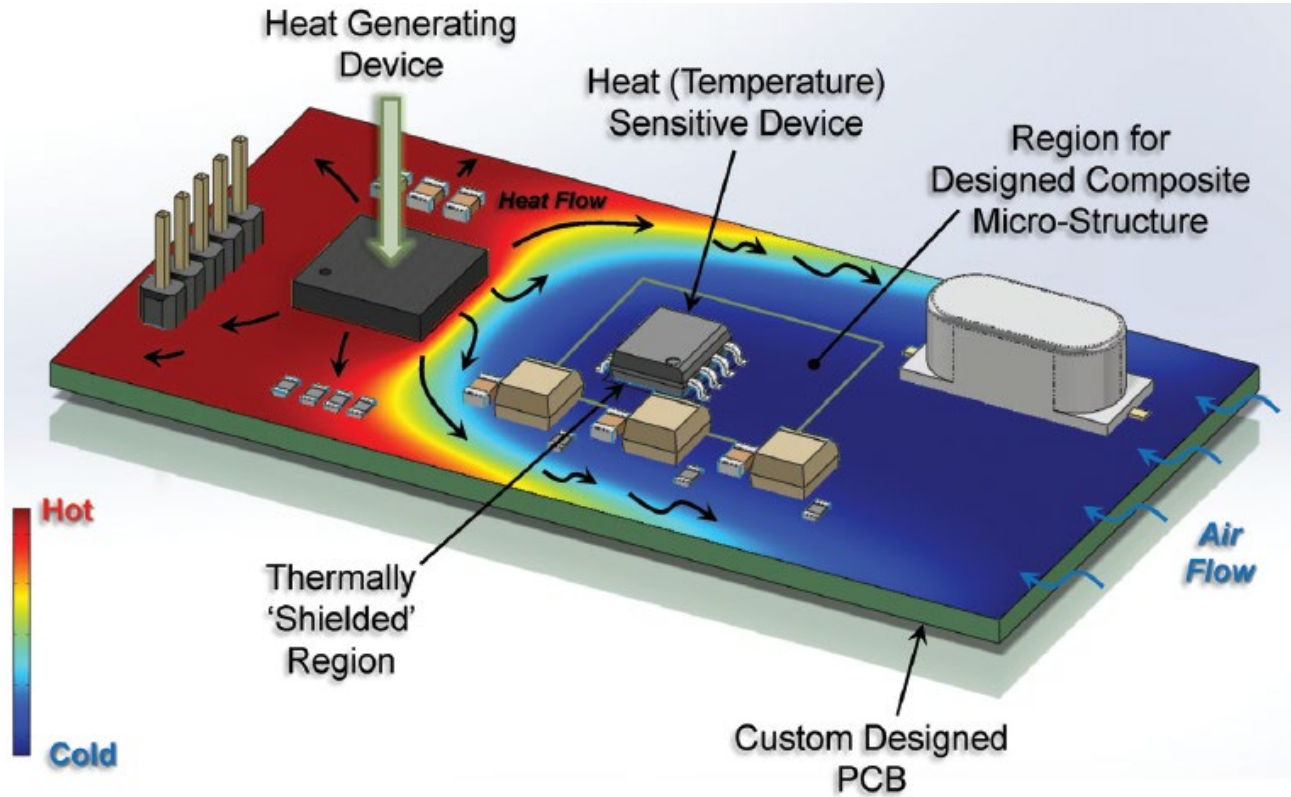
Nevidni mož



Nevidni mož



Ščitenje občutljivih komponent



6.








Toplotni tokokrogi

Toplotni superračunalnik



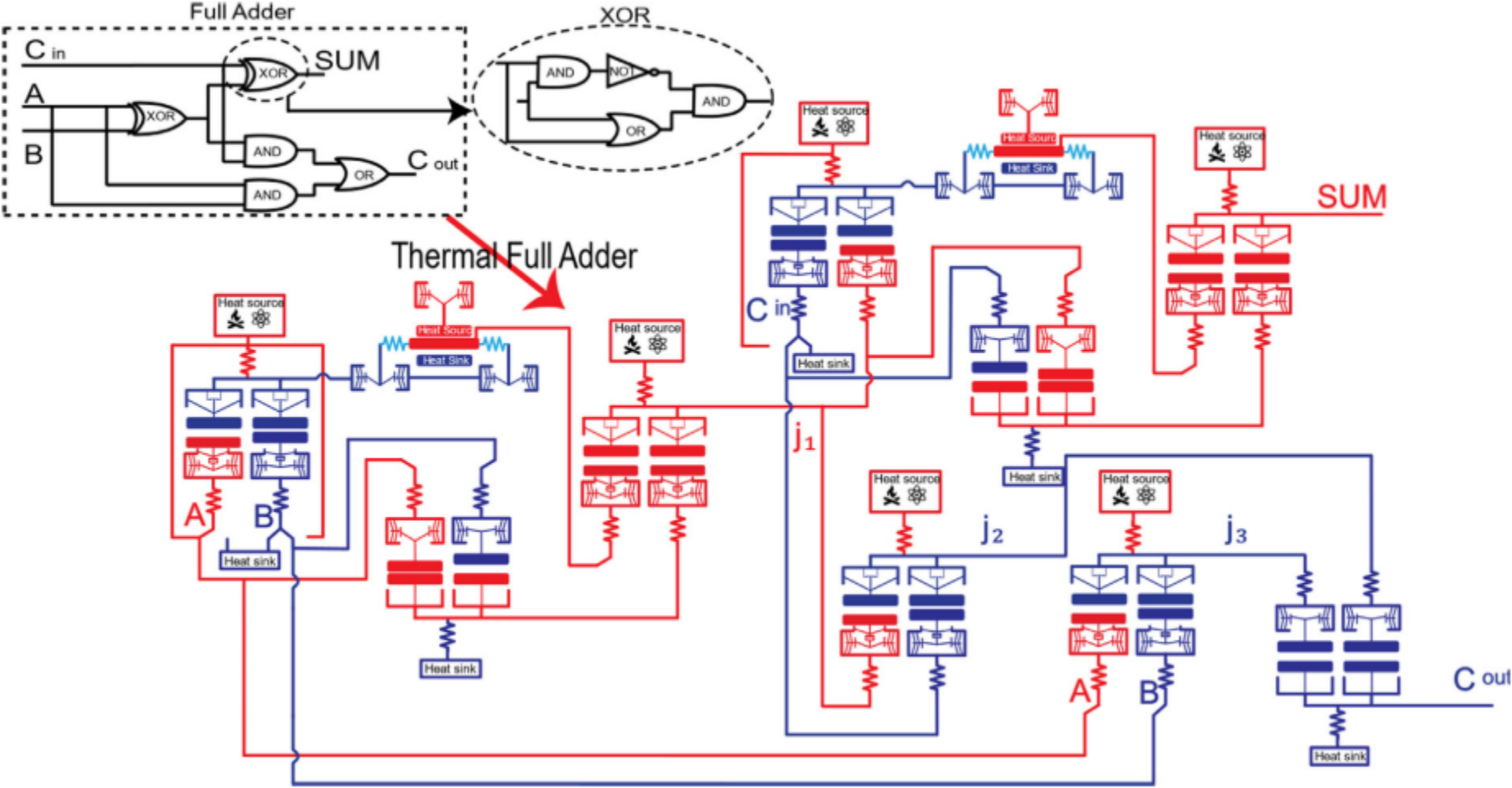
“Navaden” računalnik

© Logična 1 in 0, logične operacije

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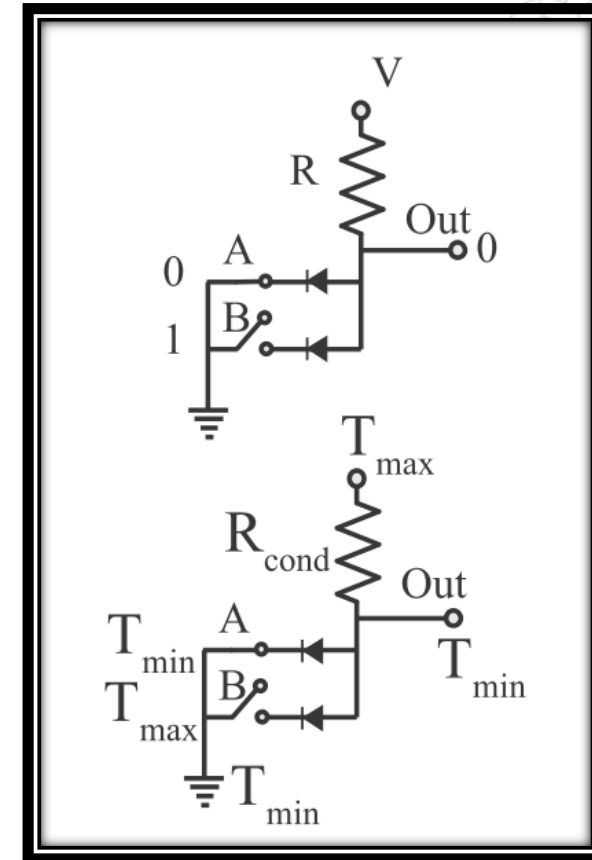
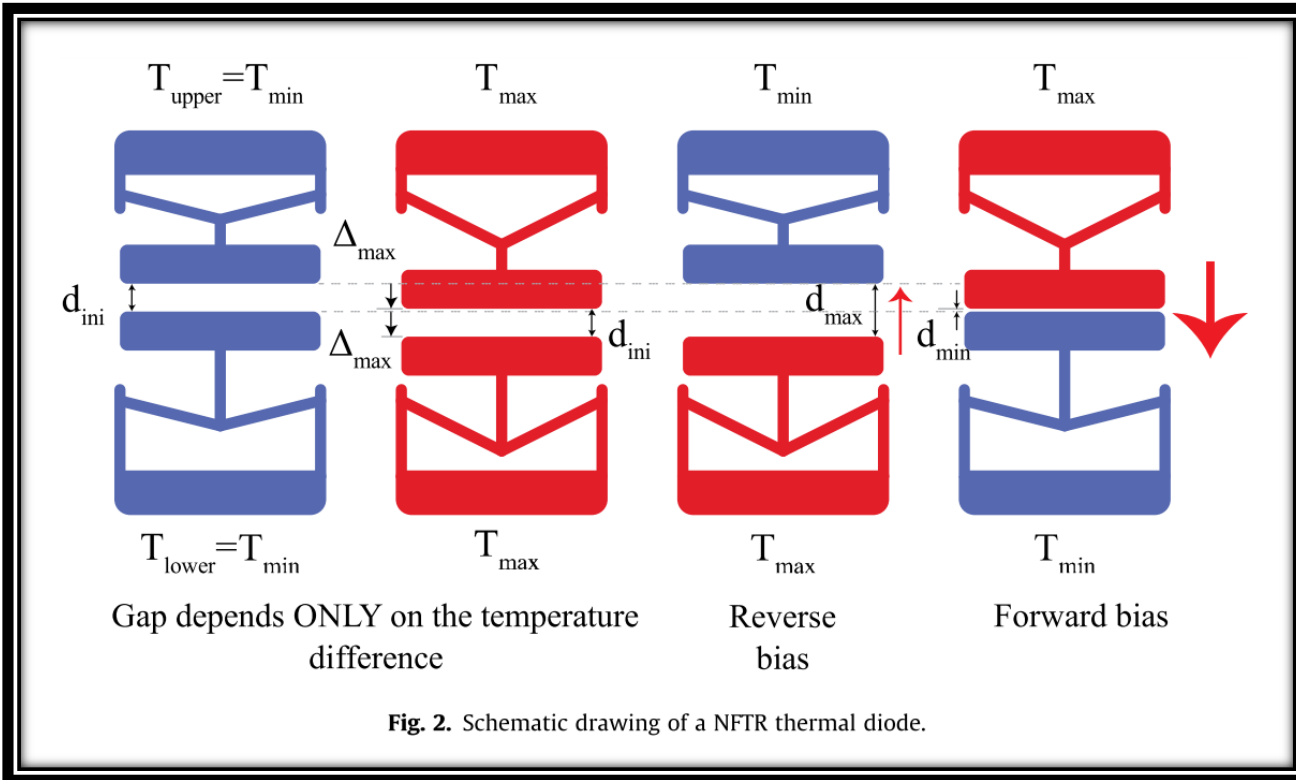
Toplotni računalnik



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Toplotni (super)računalnik

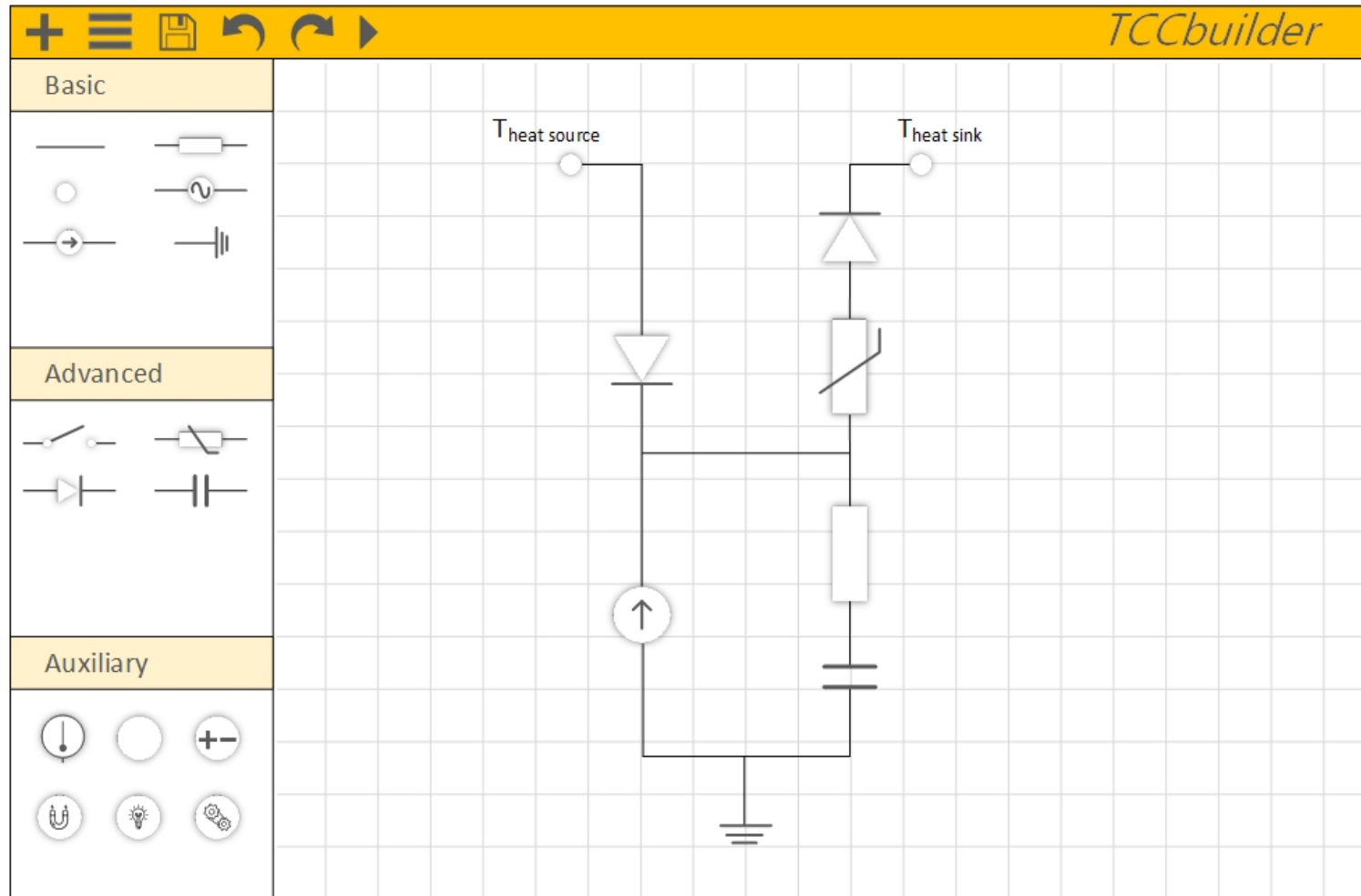


7.

Toplotni tokokrogi

Namensko orodje TCCbuilder





tccbuilder.org



Povzetek

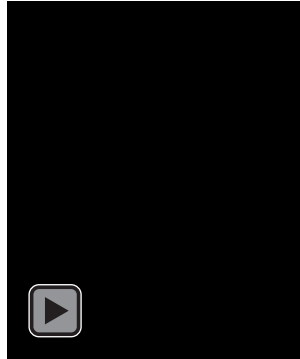
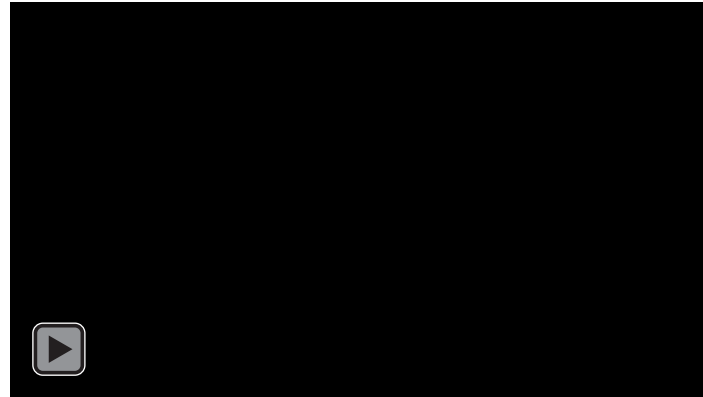
- ◎ Prihranek energije pri uporabi toplotnih kontrolnih elementov v fasadi stavbe vsaj za 1/3 (odvisno od podnebja).
- ◎ Potencial za zmanjšanje temperaturnih nihanj baterije za vsaj 10%.
- ◎ Omogočili bi lahko preboj alternativnih tehnologij hlajenja (npr. magnetno hlajenje), ki temeljijo na trdninah.

Toplotni kontrolni elementi bodo igrali pomembno vlogo pri razogličanju Evrope do leta 2050

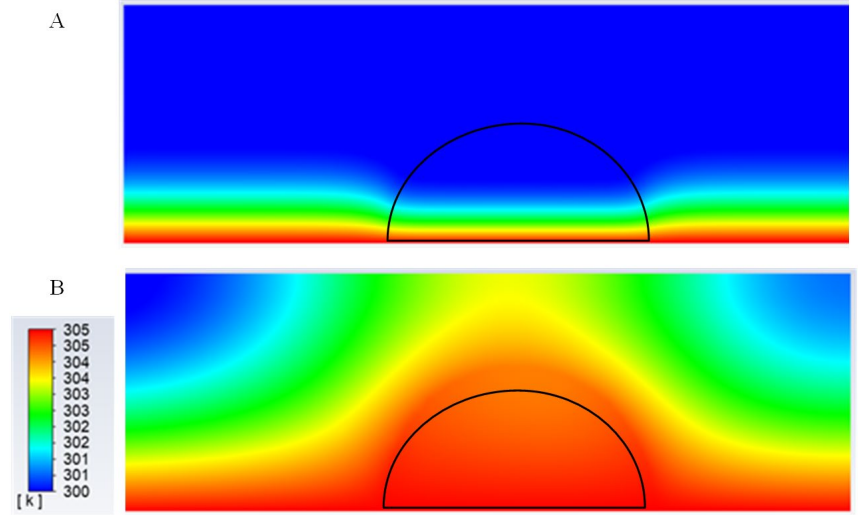


Naše delo

Toplotna stikala: mikrofluidika



Skodelica znanosti, Ljubljana, 21.9.2022



Kontakt:

spletna stran: <https://lahde.fs.uni-lj.si/>



LAHDE:

https://www.youtube.com/channel/UCrEpFT_H028T9LdgorwtujQ



@Lahde_Slovenia

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Faculty of *Mechanical Engineering*



Hvala za pozornost!

Dodatna literatura (pregledni znanstveni članki) o toplotnih kontrolnih elementih:

- Klinar K, Swoboda T, Muñoz Rojo M, Kitanovski A. Fluidic and Mechanical Thermal Control Devices. Adv Electron Mater. 2021;7(3):2000623, doi.org/10.1002/aelm.20200062
- Swoboda T, Klinar K, Yalamarthy AS, Kitanovski A, Muñoz Rojo M. Solid-state thermal control devices. Adv Electron Mater. 2021;7(3):2000625, doi.org/10.1002/aelm.20200065
- Klinar K, Kitanovski A. Thermal control elements for caloric energy conversion. Renew Sustain Energy Rev. 2020 Feb;118:109571. doi.org/10.1016/j.rser.2019.109571
- Wehmeyer G, Yabuki T, Monachon C, Wu J, Dames C. Thermal diodes, regulators, and switches: Physical mechanisms and potential applications. Appl Phys Rev. 2017;4(4). doi.org/10.1063/1.5001072
- Wong MY, Tso CY, Ho TC, Lee HH. A review of state of the art thermal diodes and their potential applications. Int J Heat Mass Transf. 2021;164. [10.1016/j.ijheatmasstransfer.2020.120607](https://doi.org/10.1016/j.ijheatmasstransfer.2020.120607)
- Roberts NA, Walker DG. A review of thermal rectification observations and models in solid materials. Int J Therm Sci [Internet]. 2011;50(5):648–62. dx.doi.org/10.1016/j.ijthermalsci.2010.12.004

