



ENERGETSKA EFIKASNOST U ZGRADARSTVU – PRORAČUNI UŠTEDA ENERGIJE, OD MVP PLATFORME DO NAPREDNIH SIMULACIJA



Konferencija SFERA 2023

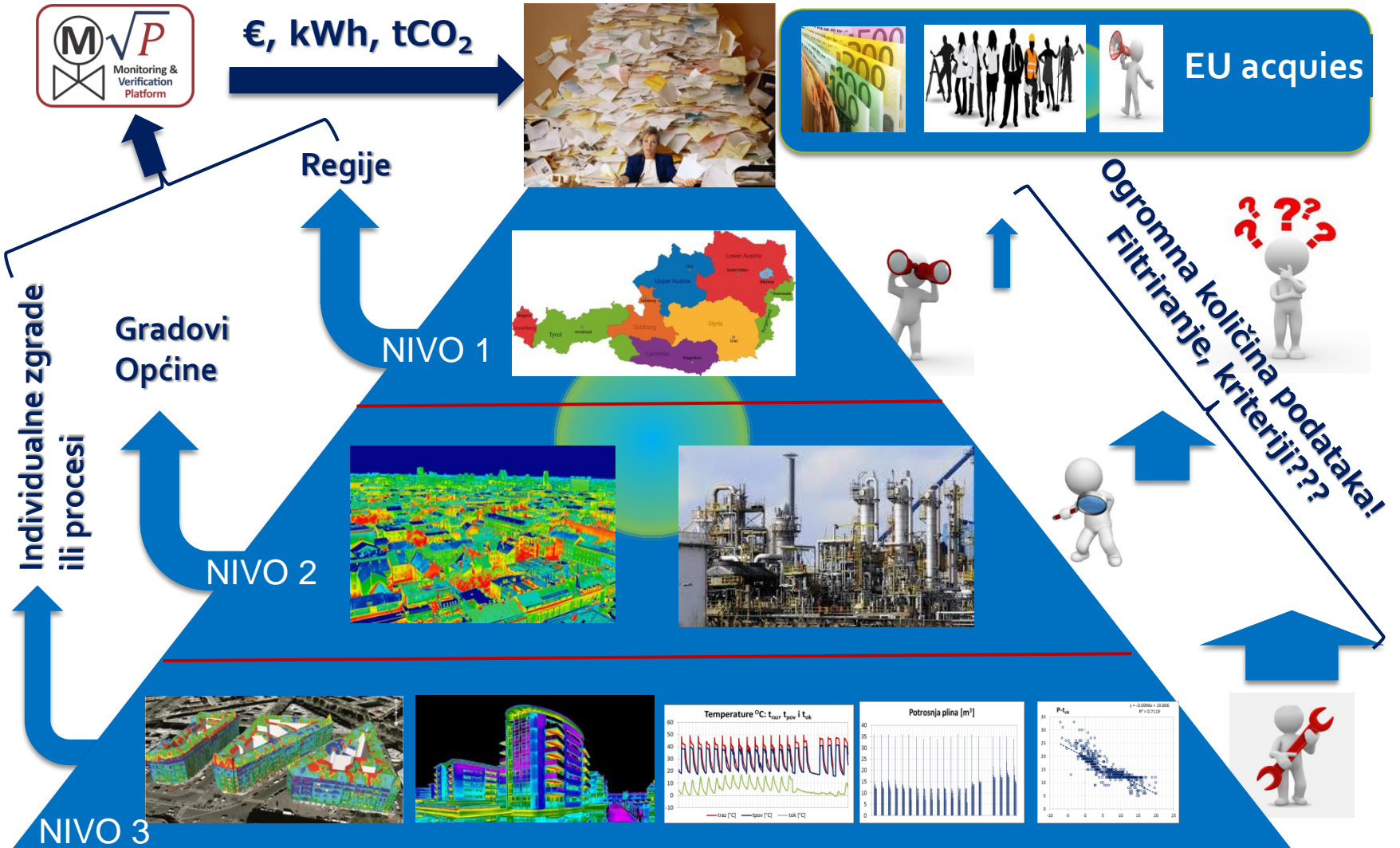
Armin Teskeredžić



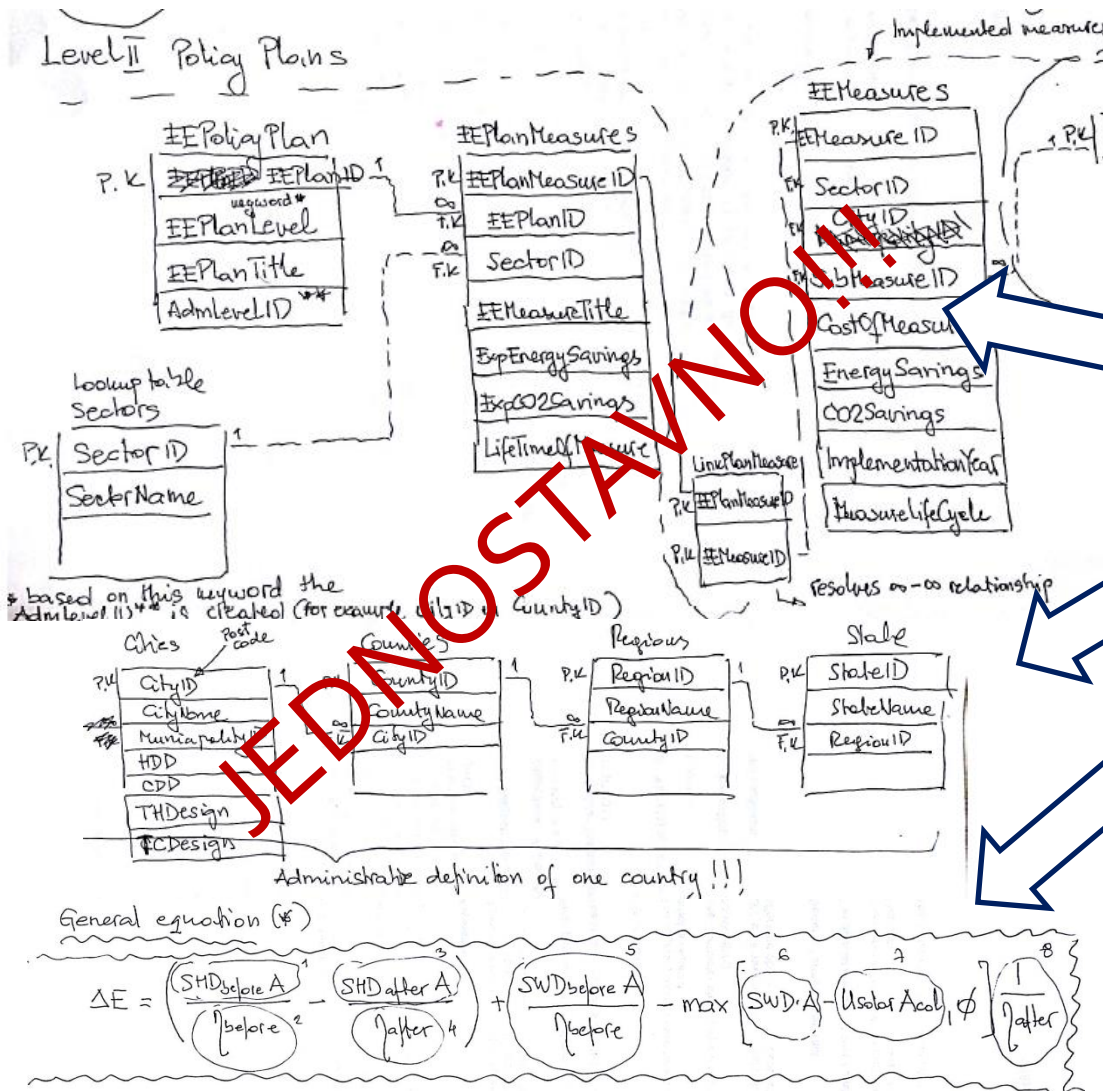
Predstavljanje

- Predavač na I i II ciklusu studija, Energetika i KGH tehnika.
- Tehnički ekspert za Sisteme daljinskog grijanja na Kosovu (WBIF),
- Pisao dio za EE u Strategiji energetike Kosova 2022,
- Tehnički dio pravilnika za član 7 EE direktive u Srbiji (key expert),
- Regionalni ekspert TABULA + cost-optimum na Kosovu.
- Ekspert za EE po pozivu u Energetskoj zajednici u Beču, 2015.
- Glavni tehnički konsultant za multEE Horizon 2020 projekat!
- Regionalni ekspert za pripremu nacionalnih planova za energetske efikasnost (NEEAP) u Srbiji, Kosovu, Crnoj Gori i Makedoniji (Albanija).
- Glavni konsultant za implementaciju SMIV (MVP) sistema u Hrvatskoj.
- Regionalni projekt menadžer pri GIZ ORF-EE, SEE region, 2009-2014.
- Kreator MVP platforme – najuspješniji regionalni projekat koji je implementiran u okviru Energetske zajednice u EE oblasti.
- Fulbright gostujući istraživač na Lawrence Berkeley National Laboratory i jedan od razvojnih inženjera *Modelica Buildings library*, Berkeley, USA, 2013.
- Prva nagrada za doktorat u USA (*Faces of the future*), 2006. godine!
- Živio u 5 svjetskih metropola i ...

Politika EE i MVP platforma!



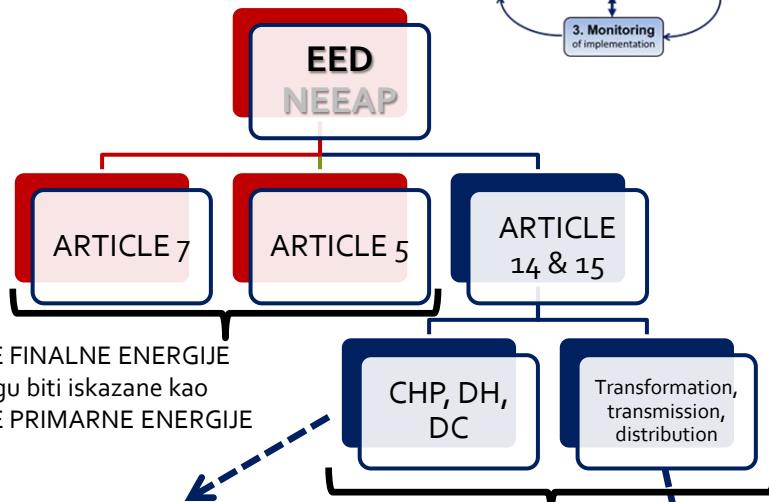
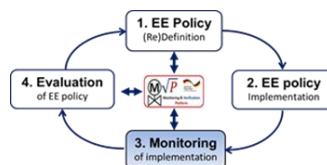
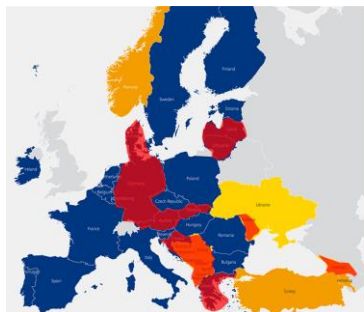
MVP Historija (početak 2013)! Nivo 1



Jasni zahtjevi:

- Proizvoljan broj planova i proizvoljan broj implementiranih mjera!
- Fleksibilna admin. struktura – radi!
- Labava specifikacija na početku!
- BU metodologija ispod haube!
- Pametni IT inženjeri koji su ovo razvijali!

MVP – potpuno usklađena s EED zahtjevima



UŠTEDE FINALNE ENERGIJE
Mogu biti iskazane kao
UŠTEDE PRIMARNE ENERGIJE

UŠTEDE PRIMARNE ENERGIJE

Primjeri: Promocija CHP, efikasni SDG & SDH, intergacija OIE, vodosnabdijevanje!



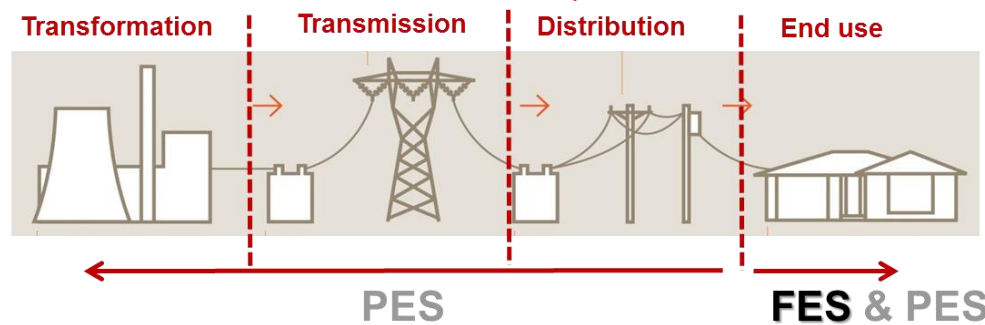
EED ciljevi (Član 3):

- *Primary energy consumption,*
- *Final energy consumption,*
- *Primary energy savings,*
- *Final energy savings,*
- *Energy intensity.*

Strateške prednosti

- Kontinuiran i sistematičan monitoring implementacije planova i EED!
- Izvještavanje EnC!
- Troškovno-optimalno rješenje!

Primjer: Električna energija

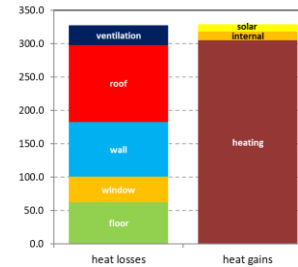


TABULA – ukratko i primjer Kosova (Nivo 2)



Energetske potrebe zgrade

CC	BUI [NO]	POP [mio]
NOR	21	5,4
BLG	26	7,0
CYP	12	1,2
SWE	10	10,0
HUN	15	9,6
KOS	19	1,9



Njemački pristup uvođenja reda

4 glavne kategorije zgrada

TABULA Energy Balance Calculation		Building Performance	
Standard Reference Calculation - based on: EN ISO 13790 / seasonal method		reference area	A_{ref} 967.2 m ²
building	XX.N.AB.02.G	conditioned floor area	(conditioned floor area)
climate	XX.N		
code construction element	original U-value	measure type	applied refurbishment measure
U _{original} W/(m ² K)	U _{actual} W/(m ² K)	A _{ext} m ²	adjustment factor soil
Roof 1	4.13	1.84 x 224.2	x 1.00 = 413.6
Roof 2		x x	=
Wall 1	1.86	1.86 x 381.0	x 1.00 = 708.7
Wall 2		x x	=
Wall 3		x x	=
Floor 1	1.34	0.96 x 205.2	x 0.50 = 98.1
Floor 2		x x	=
Window 1	3.50	3.50 x 205.0	x 1.00 = 717.5
Window 2		x x	=

Isporučena i primarna energija

TABULA Energy Balance Calculation		System Performance	
Standard Reference Calculation - based on: EN ISO 15316 / level B (tabled values)		conditioned floor area	A_{ref} 967.2 m ²
building	code XX.N.AB.02.Gen.ReEx.001.001		
system	<XX.SU.<DLB_NC.SUH.01>.<ELE.Gen.01>.<-Gen.01>.<-Gen>>		
Domestic Hot Water System			
code	XX.ELE.MUH.01		
energy need hot water	Q_{dhw} 10.0	thereof recoverable for space heating:	
+ losses distrib.	$Q_{dhw,distrib}$ 1.5	$Q_{dhw,rec}$ 0.8	
+ losses storage	$Q_{dhw,storage}$ 3.0	$Q_{dhw,loss}$ 1.5	
	$Q_{dhw,net} = Q_{dhw} + Q_{dhw,distrib} + Q_{dhw,storage}$ 14.5	$Q_{dhw,net} = Q_{dhw,rec} + Q_{dhw,loss}$ 2.3	
energypower for domestic hot water			
code	XX.E.Gen.01		
1	100%	$Q_{dhw,net}$ 14.5	E_{dhw} 15.2
2	0%	x 0.0	= 0.0
3	0%	x 0.0	= 0.0
auxiliary energy			
code	XX.C.NoCirc.SUH.01		
aux		$Q_{dhw,aux}$ 0.0	
Heating System			
code	XX.DLB_NC.SUH.01		
energy need space heating	Q_{dsh} 144.2	gain utilisation factor for heating	$f_{g,h}$

5 različitih perioda gradnje

Building Type Matrix				Republic of Kosovo			
Region	Construction Year Class	Additional Classification	SFH	TH	MFH	AB	
			Single-Family House	Terraced House	Multi-Family House	Apartment Block	
1 national (Kosovo)	... 1960	generic (tipik)	 XX.N.SFH.01.Gen	 XX.N.TH.01.Gen	 XX.N.MFH.01.Gen		
2 national (Kosovo)	1961 ... 1970	generic (tipik)	 XX.N.SFH.02.Gen	 XX.N.TH.02.Gen	 XX.N.MFH.02.Gen	 XX.N.AB.02.Gen	
3 national (Kosovo)	1971 ... 1980	generic (tipik)	 XX.N.SFH.03.Gen	 XX.N.TH.03.Gen	 XX.N.MFH.03.Gen	 XX.N.AB.03.Gen	
4 national (Kosovo)	1981 ... 1999	generic (tipik)	 XX.N.SFH.04.Gen	 XX.N.TH.04.Gen	 XX.N.MFH.04.Gen	 XX.N.AB.04.Gen	
5 national (Kosovo)	2000 ...	generic (tipik)	 XX.N.SFH.05.Gen	 XX.N.TH.05.Gen	 XX.N.MFH.05.Gen	 XX.N.AB.05.Gen	

Poređenje standardna TABULA vs. TABULA AMG



STANDARDNA TABULA

- Osnovni sistemi (1 – 4) kuplovani s jednom zgradom,
- Dva scenarija obnove (S & A), uglavnom bazirana na inženjerskoj procjeni!
- Nema podataka o investiciji!
- F_{red} faktor (19,2 to 21,4^h grijanja dnevno),
- Jedna vrijednost HDD važi za sve zgrade!
- Ne može se tražiti Troškovno-optimalno rješenje!

KOS-TABULA-AMG

- Proizvoljni sistem može biti kuplovan s bilo kojom zgradom!
- **Broj opcija obnove 2249 i više** za jednu referentnu zgradu i njen sistem!
- Sve investicije uzete u obzir!
- F_{red} faktor proizvoljna vrijednost (0 – 24^h grijanja),
- Važi za bilo koju HDD vrijednost!
- Različiti kriteriji za optimizaciju
- **Troškovno-optimalno DA!**

KOS TABULA AMG – karakteristike



Multi-kriterijski pristup do optimalnog rješenja!

ΔE_{need}	ΔE_{del}	ΔE_{prim}	ΔCO_2	An. Sav.	NPV	NPVQ	IRR
0	12,289	16,590	4.1	737	-9,102	-0.5	-2%
568,299	1,189,790	1,704,488	429.2	79,137	720,563	15.6	143%
20%	0%	0%	10%	0%	40%	0%	30%

Biraju se težinski faktori kao kriteriji pri izboru!!!

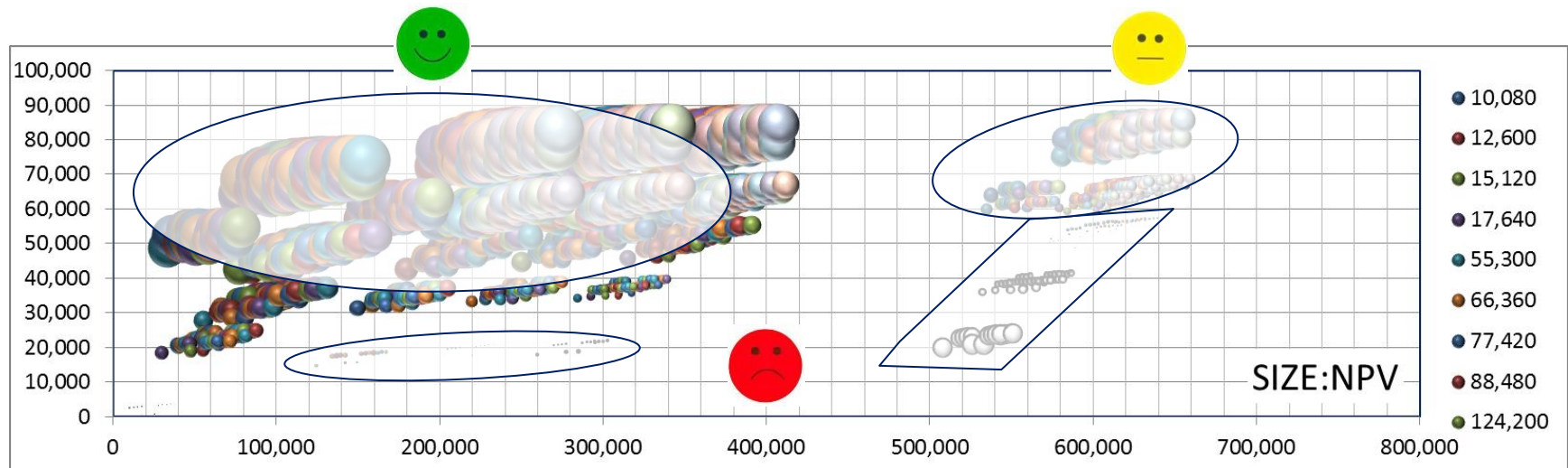
	eneed	An. Sav	Invest.	NPV	NPVQ	IRR	Meas*
$> =$							
$< =$							

Mogu se postaviti ograničavajući faktori: raspoloživi novac, Ciljani NPV i/ili IRR, ciljana vrijednost potrebne energije, ...

KOS TABULA AMG – rezultati

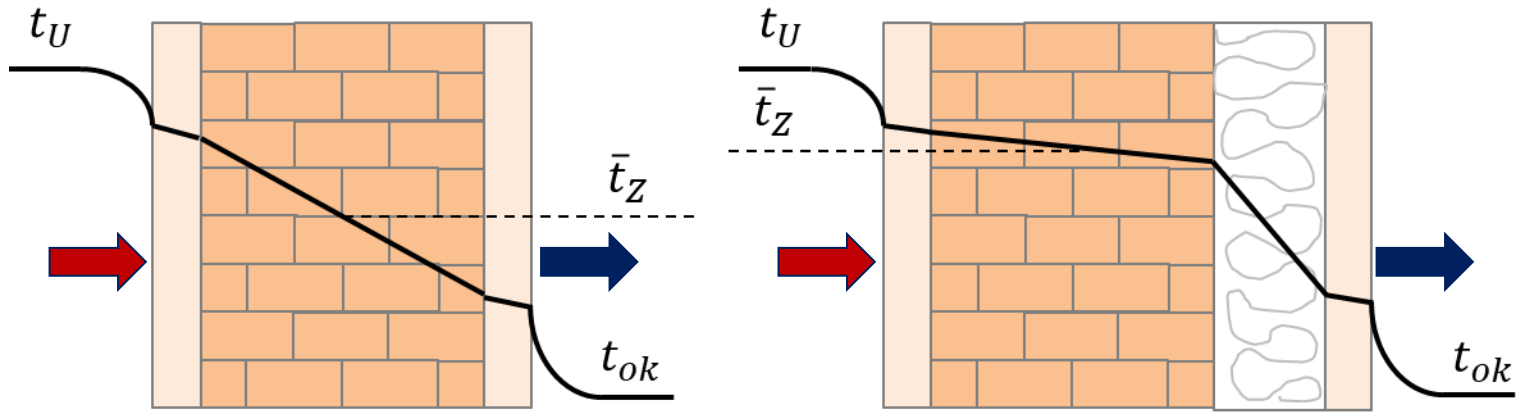


- Veličina balona proporcionalna NPV vrijednosti!
- Pozicija balona određena Investicijom (apscisa) i Uštedama (ordinata)!



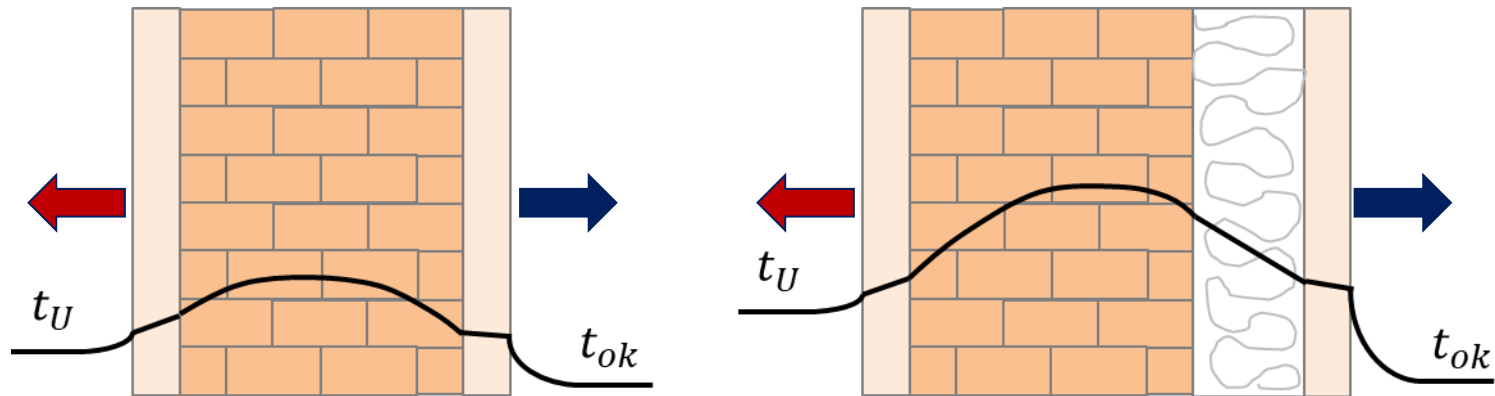
- Nakon primjene multi-kriterijske analize uz ograničavajuće faktore može se doći do optimalnog rješenja korak po korak!
- **Nepobjedivo/Unbeatable** ;-) 👍 😊

Osnove – termoizolacija zidova (NIVO 3)



Klasika

izolacija



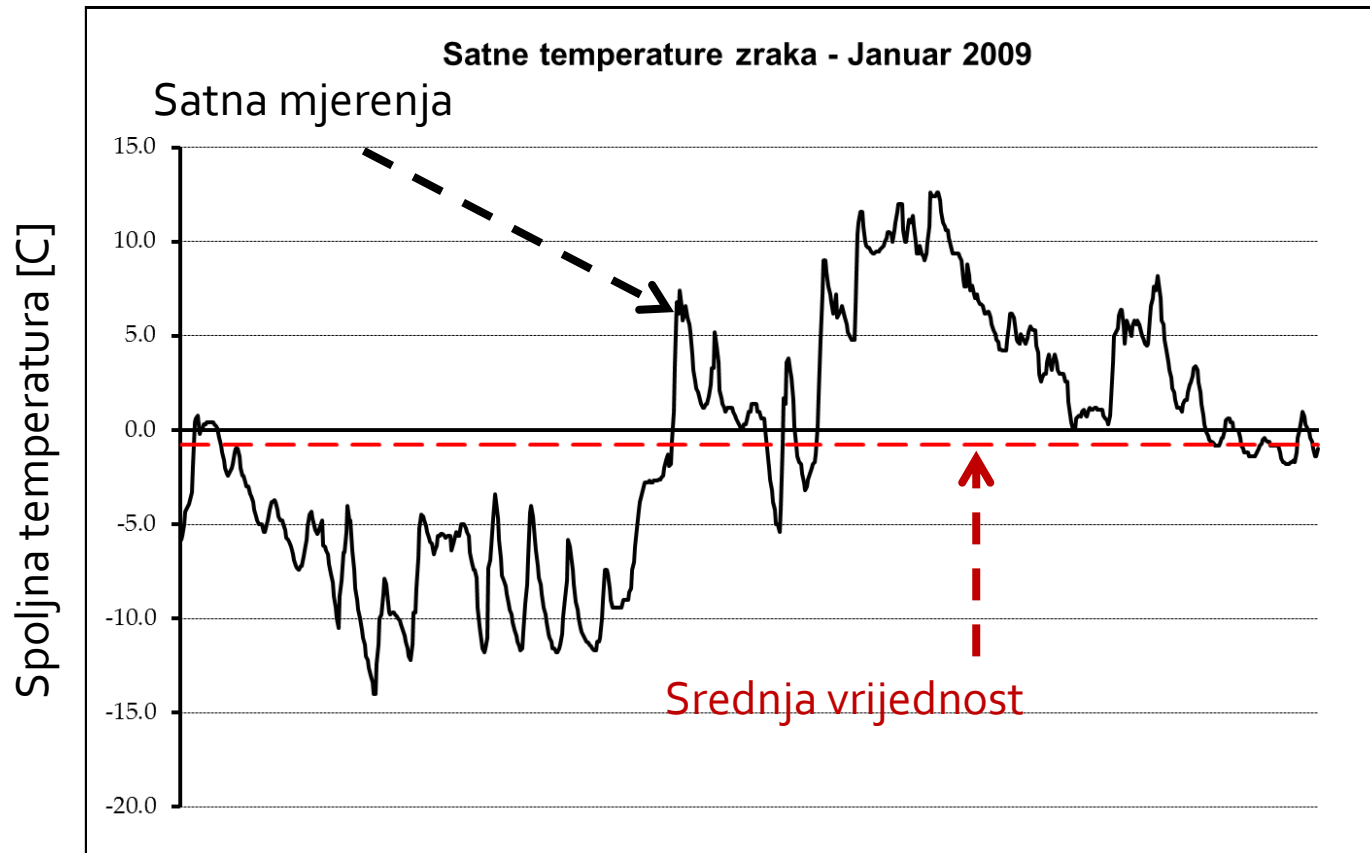
Da li je ovakav temperaturni profil u zidu moguć???

Šta je sa unutrašnjim zidovima prema grijanom prostoru?

Primjer ulaznih podataka za analize



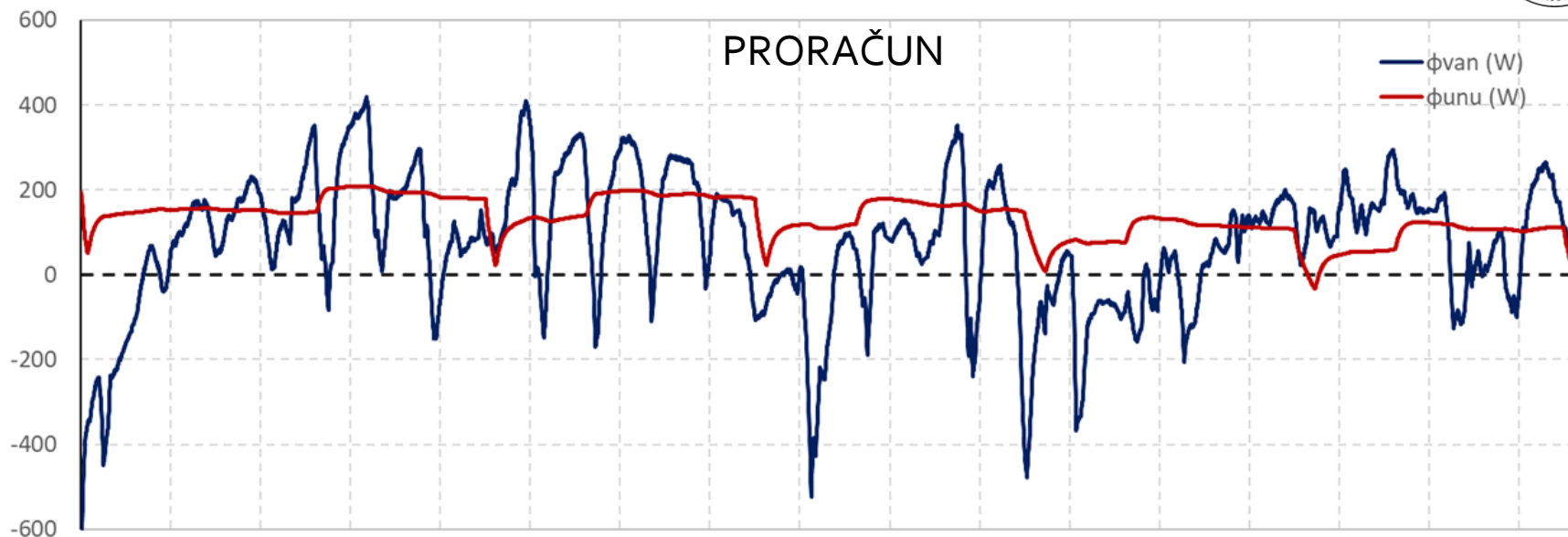
- Varijacija temperature u Sarajevu (Januar 2009)
- Možemo li naći analitičko rješenje za prethodni problem s ovom varijacijom t_{ok} ?



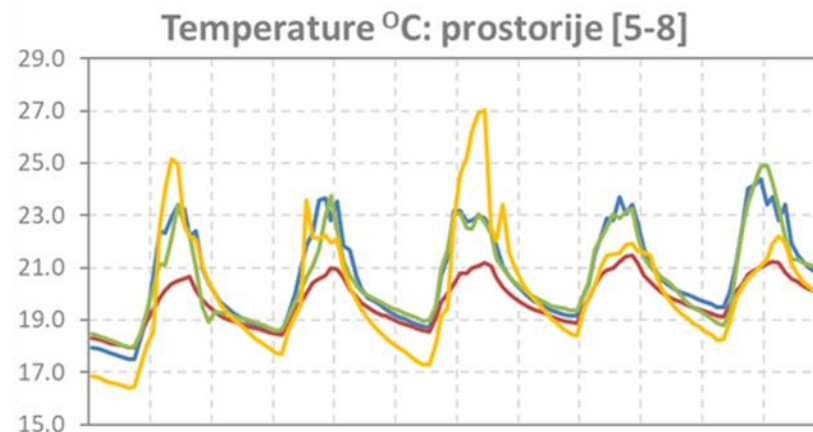
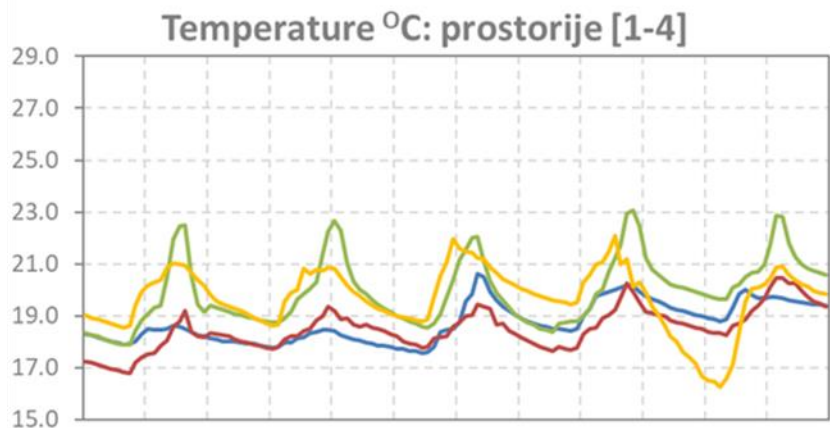
Software za nestacionarnu analizu?



PRORAČUN



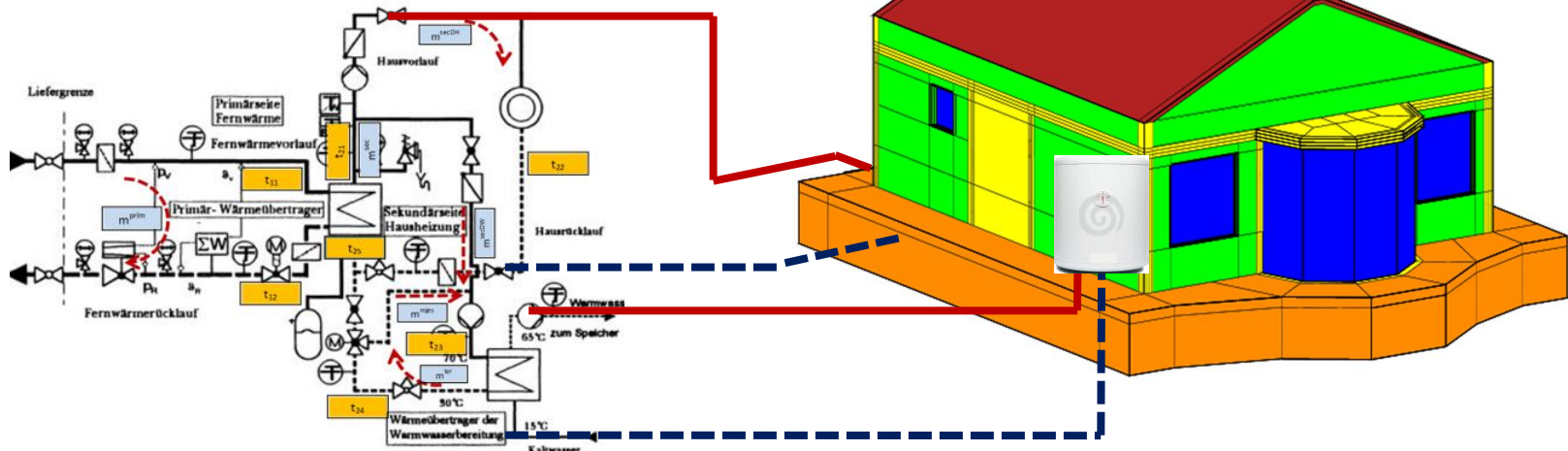
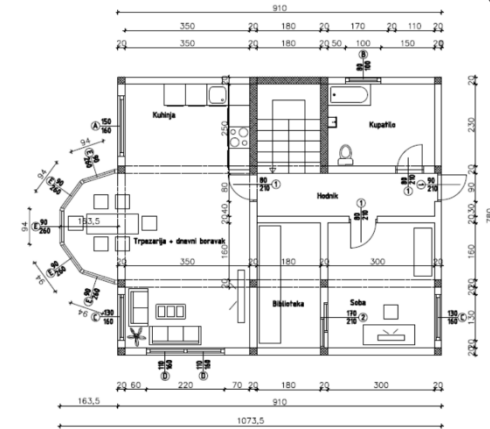
MJERENJA



Idemo još korak dublje (NIVO 3)?



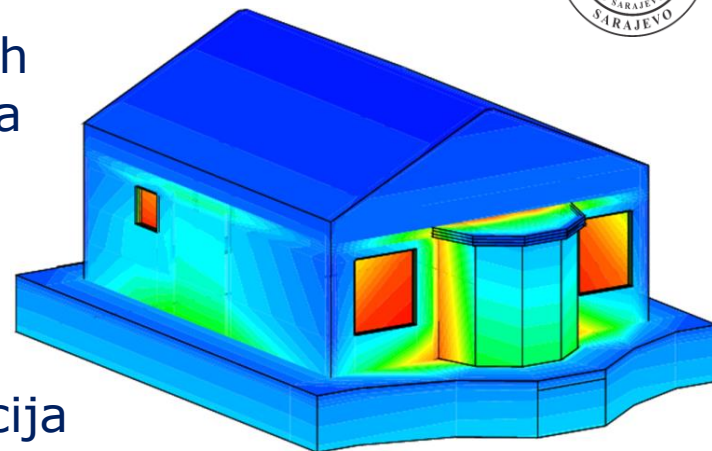
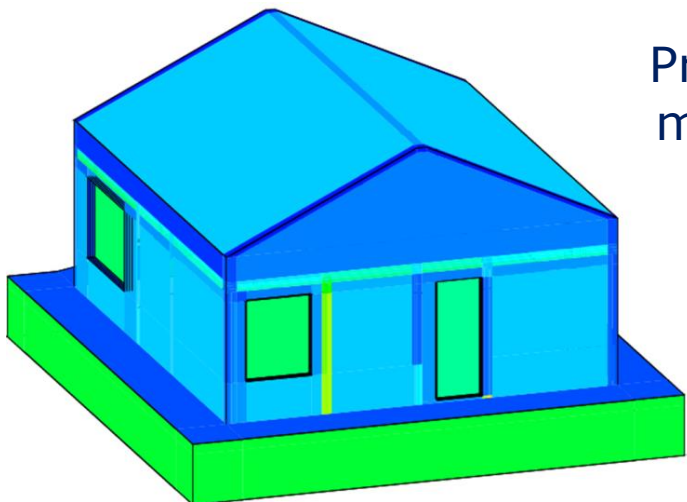
- Napredne numeričke simulacije!
- 3D model zgrade (hibridni CFD pristup),
- Rješavanje integro-diferencijalnih jednačina za zgradu i KGH sisteme!
- **Nestacionarne analize** prenosa toplote i automatike KGH sistema



Proračuni – *state of the art!*

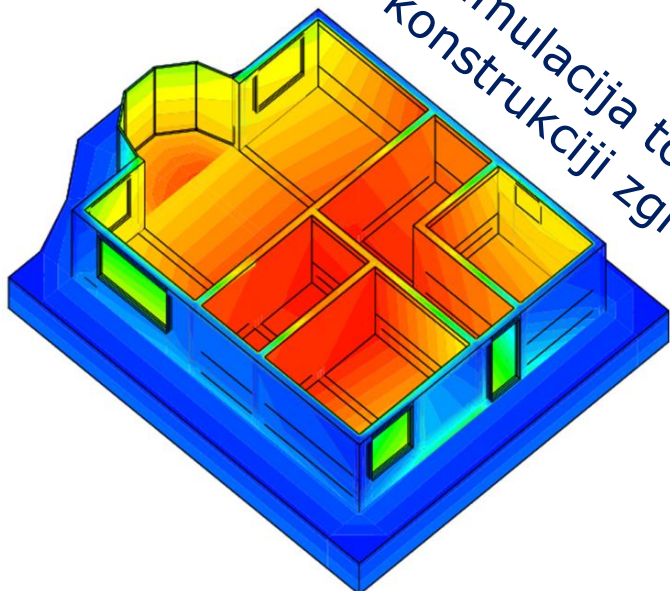


Proračun toplinskih mostova – stvarna fizika!

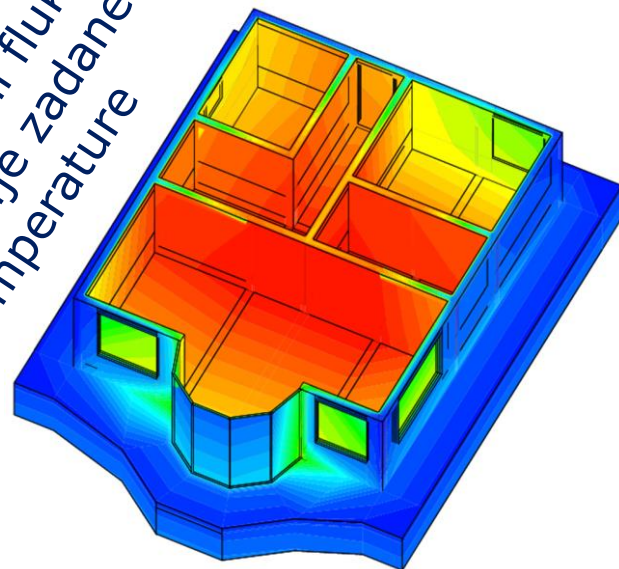


Izbor i verifikacija vodjenja sistema!

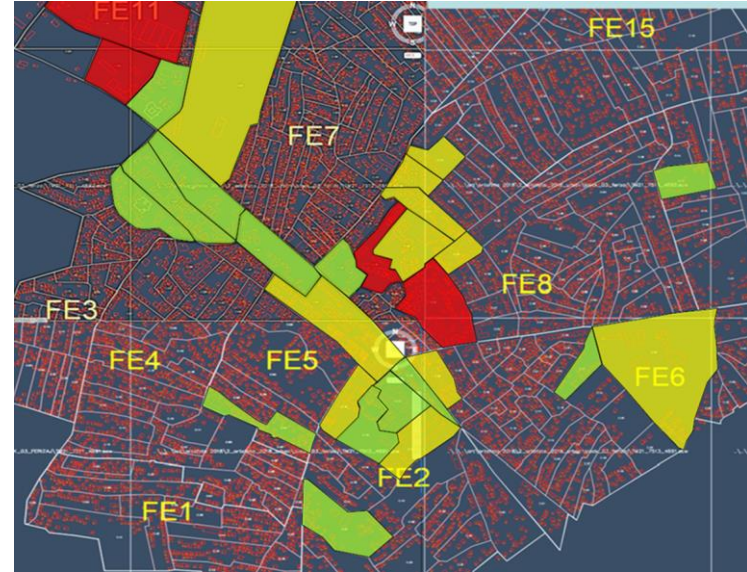
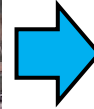
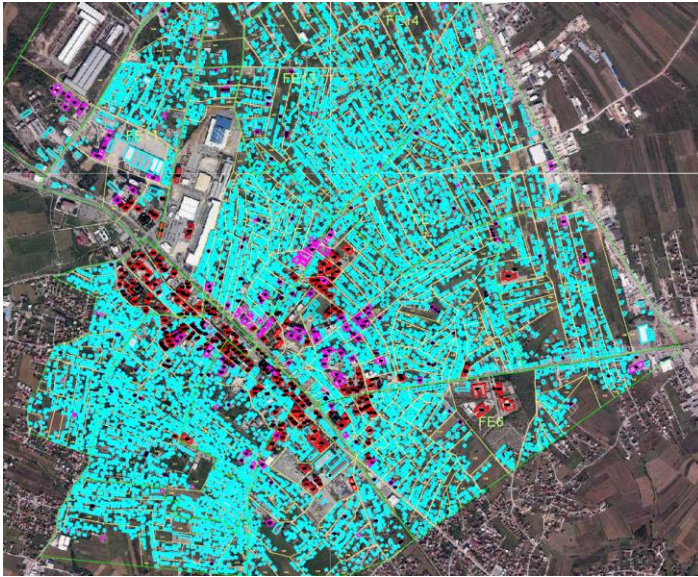
Akumulacija toplote u konstrukciji zgrade!



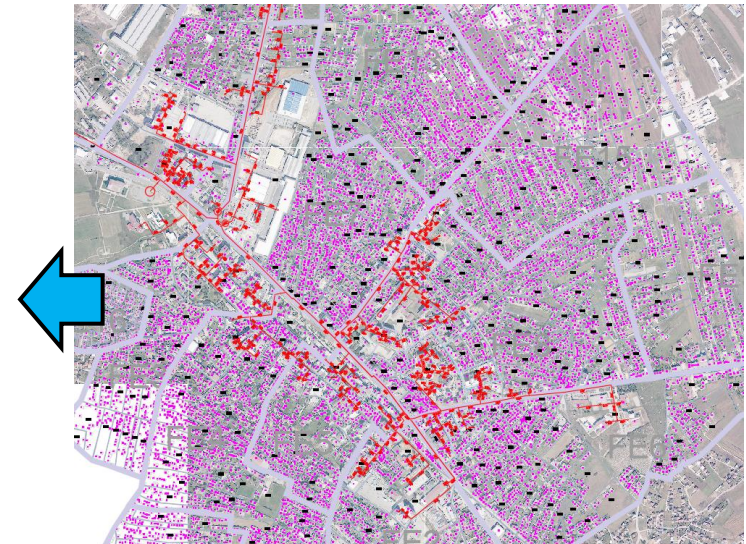
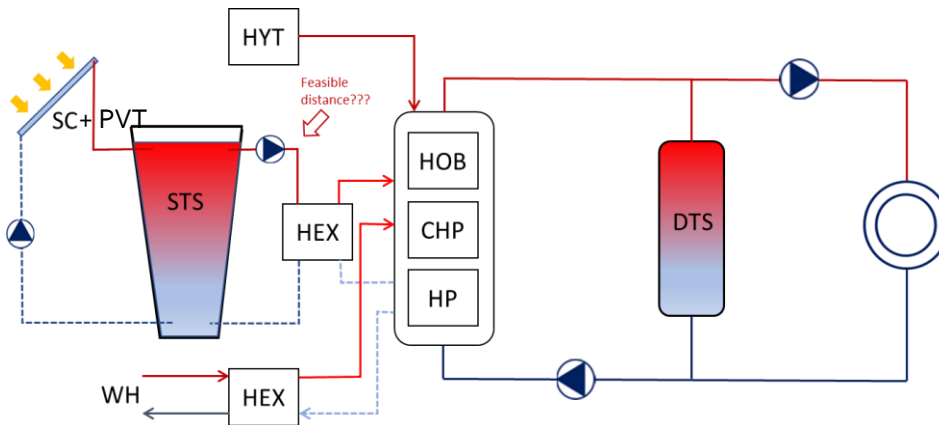
'Idealni' toplotni fluks za održavanje zadane temperature



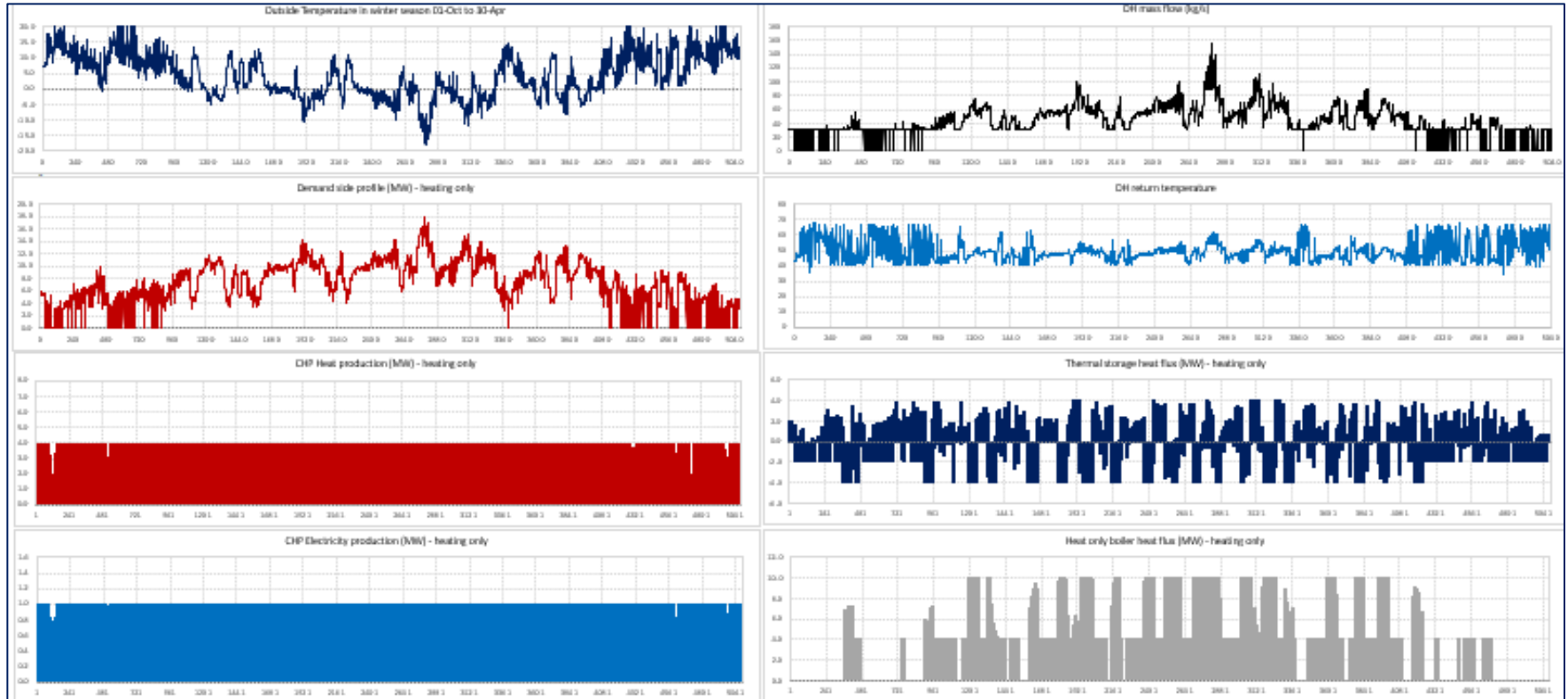
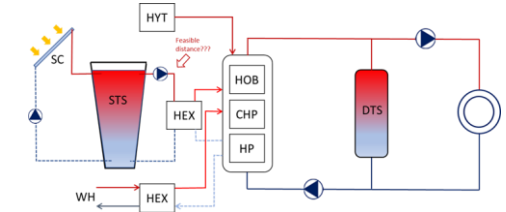
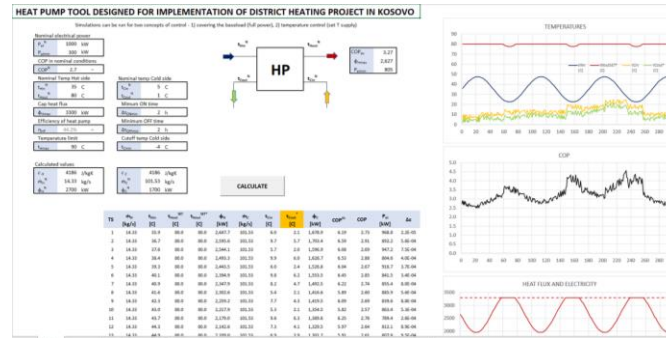
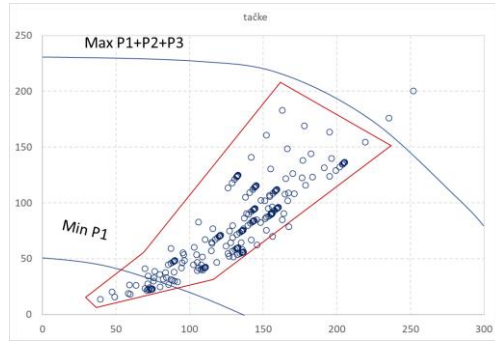
Planiranje naprednih SDG (14 hiljada mapiranih objekata)



Generički sistem daljinskog grijanja

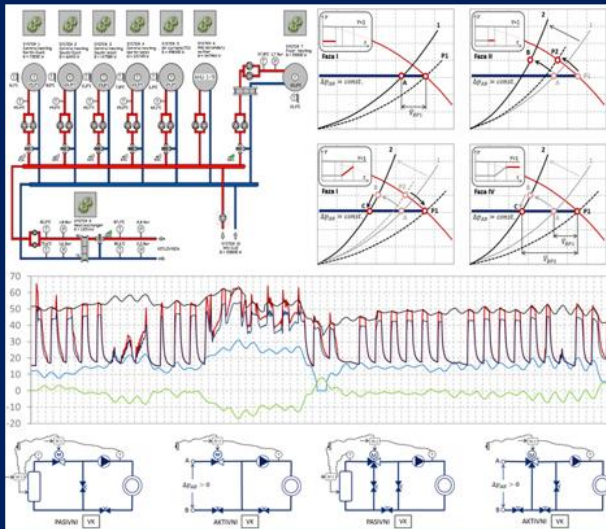


Proračuni na bazi satnih vrijednosti kritičnih parametara



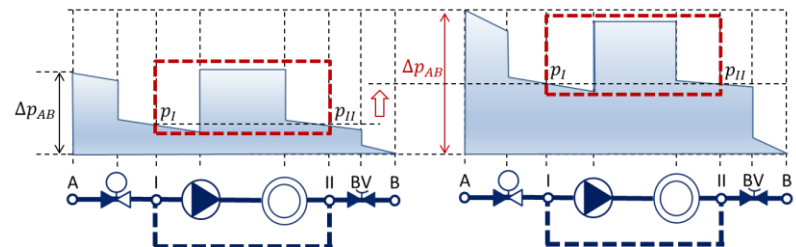
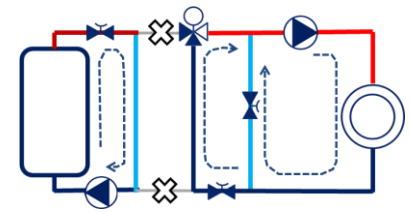
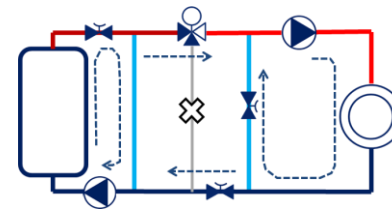
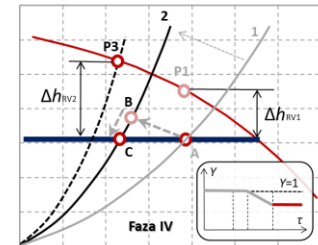
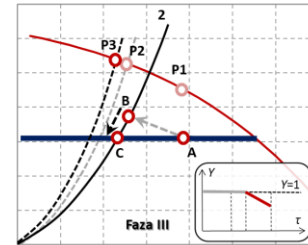
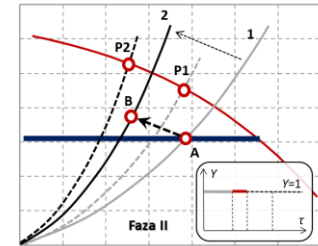
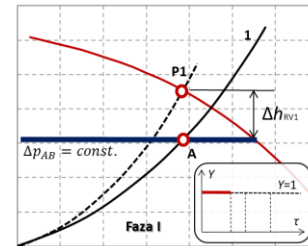
KNJIGA – Hidraulika sistema grijanja!

Toplo preporučujem, znam autora ;-)



HIDRAULIKA SISTEMA GRIJANJA

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HVALA ZA PAŽNJU!

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