Zagrebački energetski tjedan
„Razvoj ne želimo zaustaviti, ali onečišćenje možemo!”

RePublic ZEB projekt:
Troškovna optimizacija energetske obnove zgrada

Toni Borković
Energetski institut Hrvoje Požar

Zagreb, 11.5.2016.

Osnovne informacije o projektu

- Kljucni cilj projekta je odrediti troškovno korisne „pakete mjera“ bazirane na ucinkovitim tehnologijama garantirane kvalitete za energetsku obnovu fonda javnih zgrada prema zgradama gotovo nulte energije, koji ce biti standardizirani i prihvaceni od vlasnika zgrada
- Koraci:
  - utvrdivanje trenutnog stanja fonda javnih zgrada kroz vrednovanje potrošnje energije i emisije CO_2 na nacionalnoj razini,
  - definiranje referentnih zgrada
  - razvoj zajednickih okvira i ujednacene metodologije za definiciju koncepta zgrada gotovo nulte energije za javne zgrade

Projektni partneri

- BME Budapesti Műszaki és Gazdaságtudományi Egyetem
- BRE Building Research Establishment
- BSERC Black Sea Energy Research Centre
- CRES Centre for Renewable Energy Sources and Saving
- CTI Comitato Termotecnico Italiano
- Energetski institut Hrvoje Pozar
- Institutul national de cercetare-dezvoltare in constructii urbanism si dezvoltare teritoriala durabila
- IREC Institut de Recerca en Energia de Catalunya
- LNEG Laboratório Nacional de Energia e Geologia I.P
- ЦЕНТАР ЗА ЕНЕРГЕТСКА ЕФИКАСНОСТ НА МАКЕДОНИЈА
- POLITO Politecnico di Torino
- ZRMK Gradbeni inštitut ZRMK

Pozadina projekta

- NZEB, unatoč činjenici da je za javne zgrade obavezan standard gradnje novih zgrada iza 2018. godine, u većini članica EU nije zaživio kao specifična kategorija gradnje i opremanja zgrada
- Zahtjevi koje bi zgrada kod rekonstrukcije morala postići kako bi bila prepoznata kao NZEB identični su zahtjevima za nove zgrade ili nisu uopće određeni
- Udio novih zgrada u ukupnom fondu javnih zgrada iza 2018. godine će vrlo polako rasti nadomještanjem postojećih ili proširenjem kapaciteta novim zgradama, te se zbog dugog životnog vijeka zgrada ne može očekivati značajan napredak u povećanju broja rekonstrukcija zgrada prema zahtjevima NZEB

Glavni ciljevi projekta

- Glavni ciljevi projekta:
  - utvrdivanje trenutnog stanja fonda javnih zgrada kroz vrednovanj potrošnje energije i emisije CO2 na nacionalnoj razini,
  - definiranje referentnih zgrada
  - razvoj zajednickih okvira i ujednacene metodologije za definiciju koncepta zgrada gotovo nulte energije za javne zgrade

Najznačajniji rezultati projekta

- **Analiza fonda javnih zgrada i definicija referentnih zgrada**
  - Prikupljanje podataka i analiza potrošnje energije javnih zgrada u svakoj ciljnoj državi, ukljucujuci grijanje, pripremu potrošne tople vode, hladenje i rasvjetu
  - Ova je analiza usko vezana uz ciljeve RePublic_ZEB projekta i koristi podatke IEA, IEE i EASME (ranije EACI) – npr. DATAMINE
  - Analiza nacionalnih podataka daje usporedbu medu zemljama s ciljem odredivanja indikatora energetske ucinkovitosti za razlicite vrste javnih zgrada prema namjeni, velicini i nacinu korištenja
  - Razvoj niza standardnih troškovno ucinkovitih mjera (paketa mjera) za stvaranje ciljnih grupa javnih zgrada – modela

Najznačajniji rezultati projekta

- **Utvrdivanje trenutnog stanja i analiza mogucnosti obnove javnih zgrada prema zgradama gotovo nulte energije**
  - prepoznavanje najprikladnijih tehnoloških rješenja na tržištu kojima bi se postigao cilj zgrada gotovo nulte energije za javne zgrade
  - Rezultati ranijih EU projekata (npr. ENTRANZE, Annex 52 i Annex 53)

Najznačajniji rezultati projekta

- **Cost/benefit analiza „paketa mjera“ za obnovu prema zgradama gotovo nulte energije**
  - referentne zgrade i paketi mjera u pogledu potencijala ušteda energije i smanjenja troška.
  - Generalni cilj je povecanje povjerenja gradevinske industrije i pružanje alata za odabir najpodesnijih i troškovno optimalnih tehnologija
  - Usporedba medu državama i analiza osjetljivosti
  - Primjena troškovno optimalne metodologije

Najznačajniji rezultati projekta

- **Strategije i smjernice za zgrade gotovo nulte energije**
  - razvoj smjernica za ubrzanje rekonstrukcija javnih zgrada prema standardima zgrada gotovo nulte energije.
  - niz preporuka politike omogucavanja implementacije standarda zgrada gotovo nulte energije
  - bottom-up pristup za obnovu i na razinu zgrada gotovo nulte energije

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Zahtjevi za zgrade gotovo nulte energije

Pregled nacionalnih definicija zgrada gotovo nulte energije dobiven iz do sada publiciranih rezultata projekta **neZEH** - Nearly zero energy hotels, koji pokriva sedam članica – Grčka, Hrvatska, Španjolska, Italija, Francuska, Rumunjska i Švedska

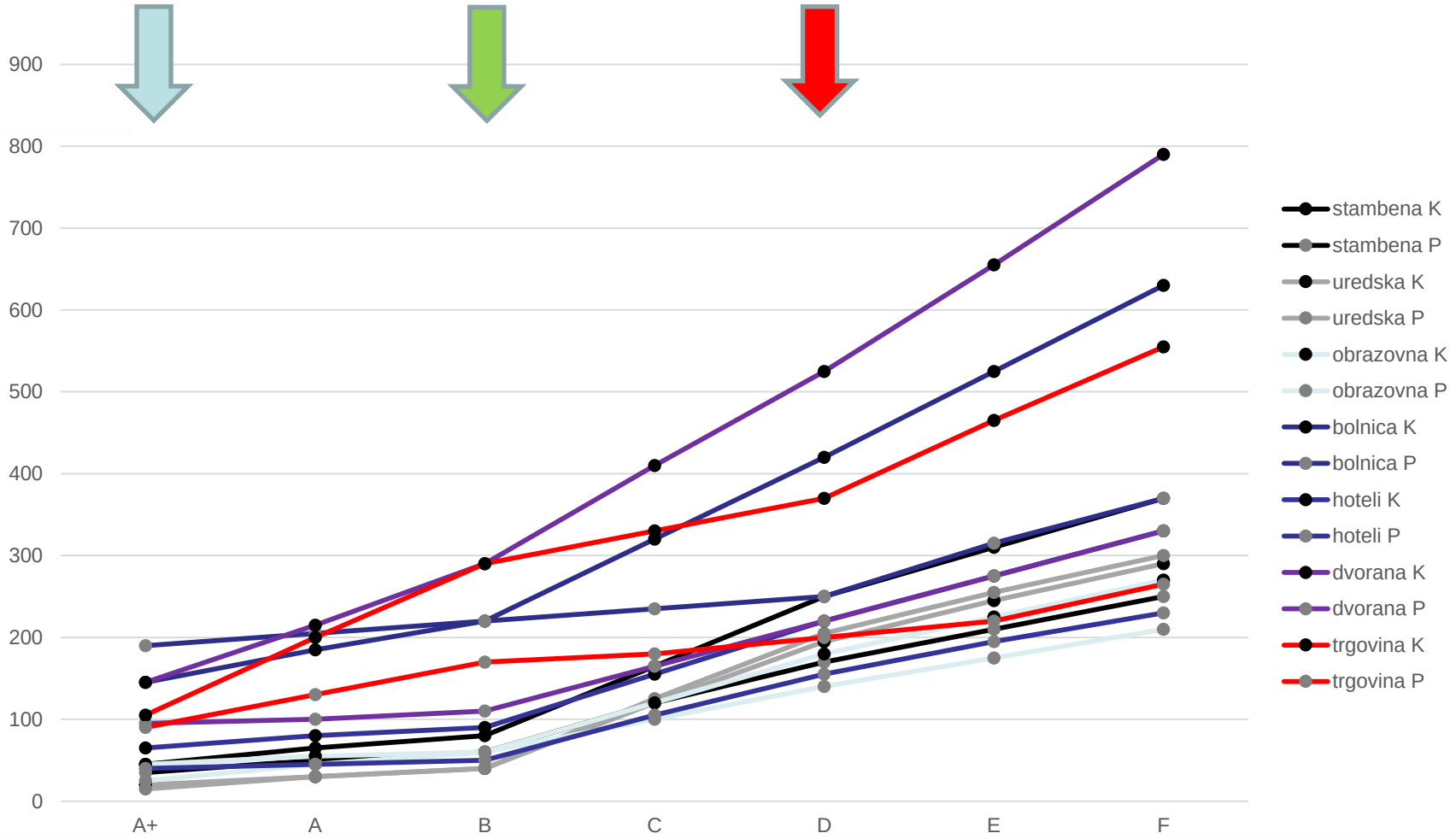
Zahtjevi su definirani u specifičnoj primarnoj godišnjoj energiji po površini osim u Danskoj i Litvi gdje je zahtjev iskazan relativno u odnosu na minimalne zahtjeve propisa

Cipar	180	stambena
	210	nestambena
Slovačka	32	stambena zgrada
	54	obiteljska kuća
	60	uredska zgrada
	34	škola
Belgija - Bruxelles	45	jednoobiteljska zgrada
	95-2,5 (V/S)	uredska zgrada
	95-2,5 (V/S)	škola
Belgija - Valonija	60	stambene zgrade, škole, uredi i zgrade uslužnog sektora
Belgija - Flandrija	30	stambene zgrade
	40	uredske zgrade, škole
Francuska	50	stambene zgrade
	70	uredske zgrade bez klimatizacije
	110	uredske zgrade s klimatizacijom
Irska	45	stambene zgrade
Nizozemska	0	stambene i nestambene zgrade
Danska	20	stambene zgrade
	25	nestambene zgrade
Estonija	90	samostojeće kuće
	100	višestambene zgrade
	100	uredske zgrade
	130	hoteli i restorani
	120	javne zgrade
	130	trgovački centri
	90	škole
	100	vrtići
	270	bolnice
Latvija	95	stambene i nestambene zgrade
Litva	< 25% C	stambene i nestambene zgrade

Zahtjevi za zgrade gotovo nulte energije - E_{prim}

razred	A+		A		B		C		D		E		F		G	
	Primarna energija za potrebe zgrade prema EPBD $E_{prim} \leq$															
Referentna klima	K	P	K	P	**K**	**P**	K	P	K	P	K	P	K	P	K	P
Stambena zgrada	**45**	**35**	65	50	**80**	**60**	165	120	250	170	310	210	370	250	>370	>250
Obiteljska kuća	**40**	**30**	60	40	**80**	**50**	175	120	270	190	340	240	400	280	>400	>280
Uredska zgrada	**20**	**15**	30	30	**40**	**40**	120	125	195	205	245	255	290	300	>290	>300
Zgrada za obrazovanje	**45**	**25**	55	45	**60**	**60**	120	100	180	140	225	175	270	210	>270	>210
Bolnice	**145**	**190**	185	205	**220**	**220**	320	235	420	250	525	315	630	370	>630	>370
Hoteli i restorani	**65**	**40**	80	45	**90**	**50**	155	105	220	155	275	195	330	230	>330	>230
Sportske dvorane	**145**	**95**	215	100	**290**	**110**	410	165	525	220	655	275	790	330	>790	>330
Zgrade za trgovinu	**105**	**90**	200	130	**290**	**170**	330	180	370	200	465	220	555	265	>555	>265

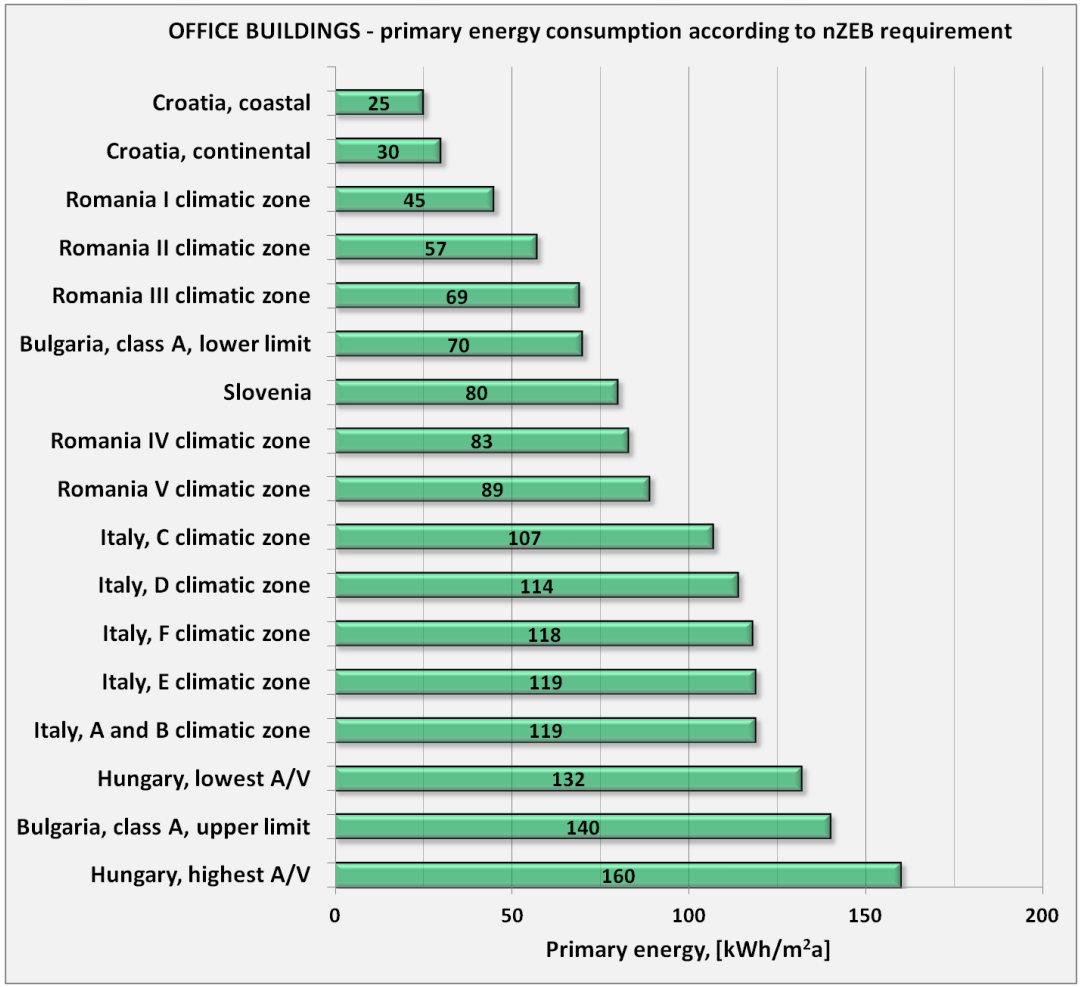
Zahtjevi za zgrade gotovo nulte energije - E_{prim}



Zahtjevi za zgrade gotovo nulte energije
RePublic ZEB – uredske zgrade

Usporedba zahtjeva za nZEB zgrade u IEE projektu RePublic_ZEB

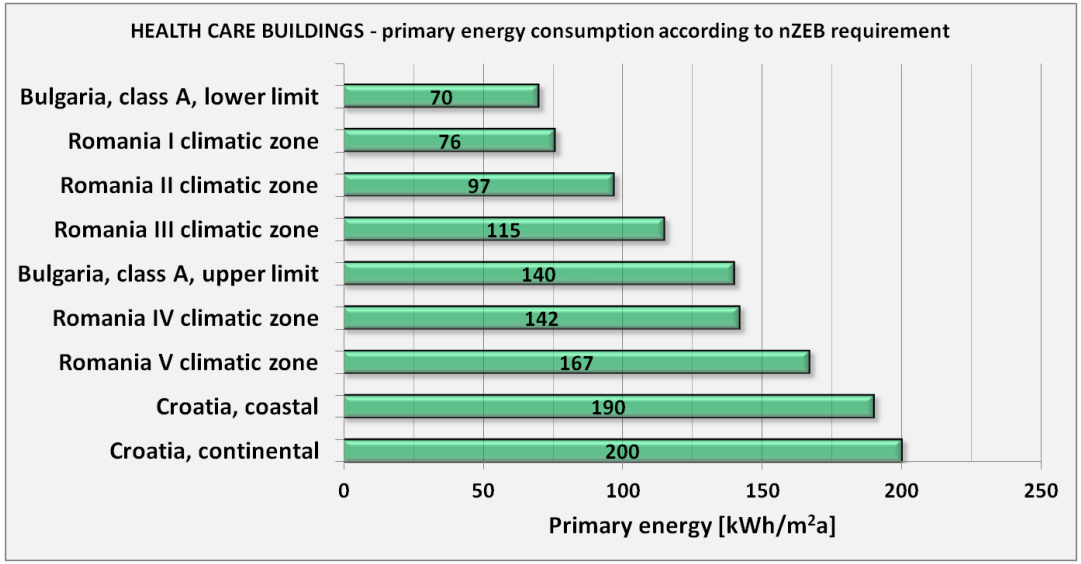
Korišteni podaci su neslužbeni podaci prikupljeni na početku projekta, te su prisutna odstupanja od naknadno definiranih zahtjeva u regulativi



Zahtjevi za zgrade gotovo nulte energije
RePublic ZEB – zgrade za zdravstvo

Usporedba zahtjeva za nZEB zgrade u IEE projektu RePublic_ZEB

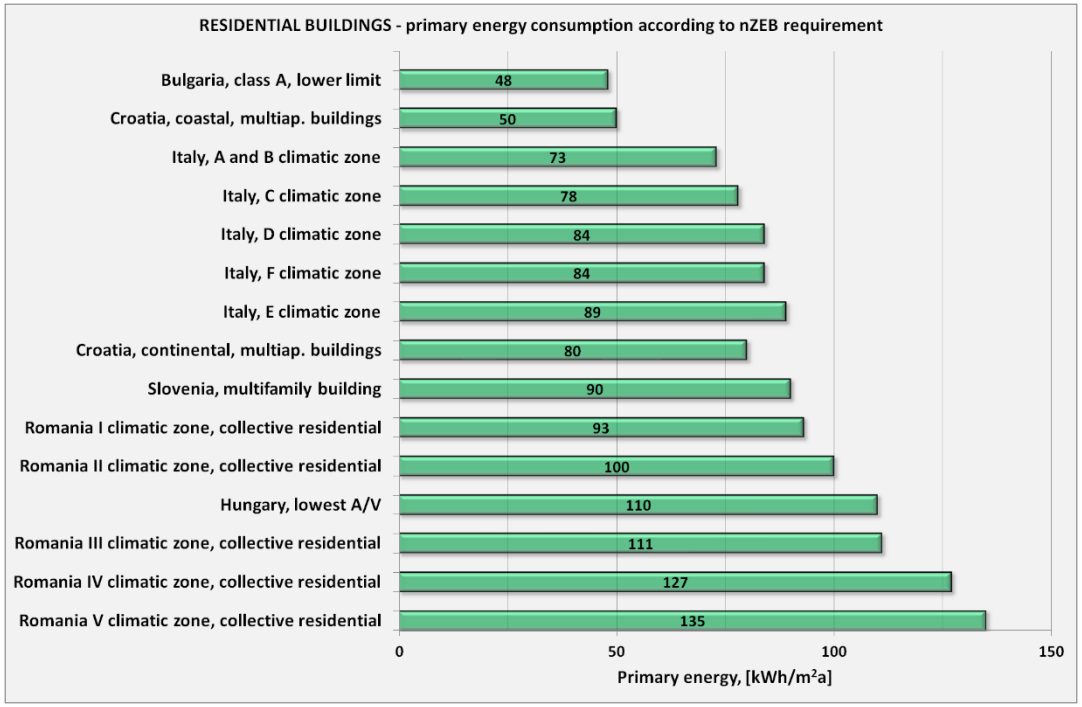
Korišteni podaci su neslužbeni podaci prikupljeni na početku projekta, te su prisutna odstupanja od naknadno definiranih zahtjeva u regulativi



Zahtjevi za zgrade gotovo nulte energije
RePublic ZEB – stambene zgrade

Usporedba zahtjeva za nZEB zgrade u IEE projektu RePublic_ZEB

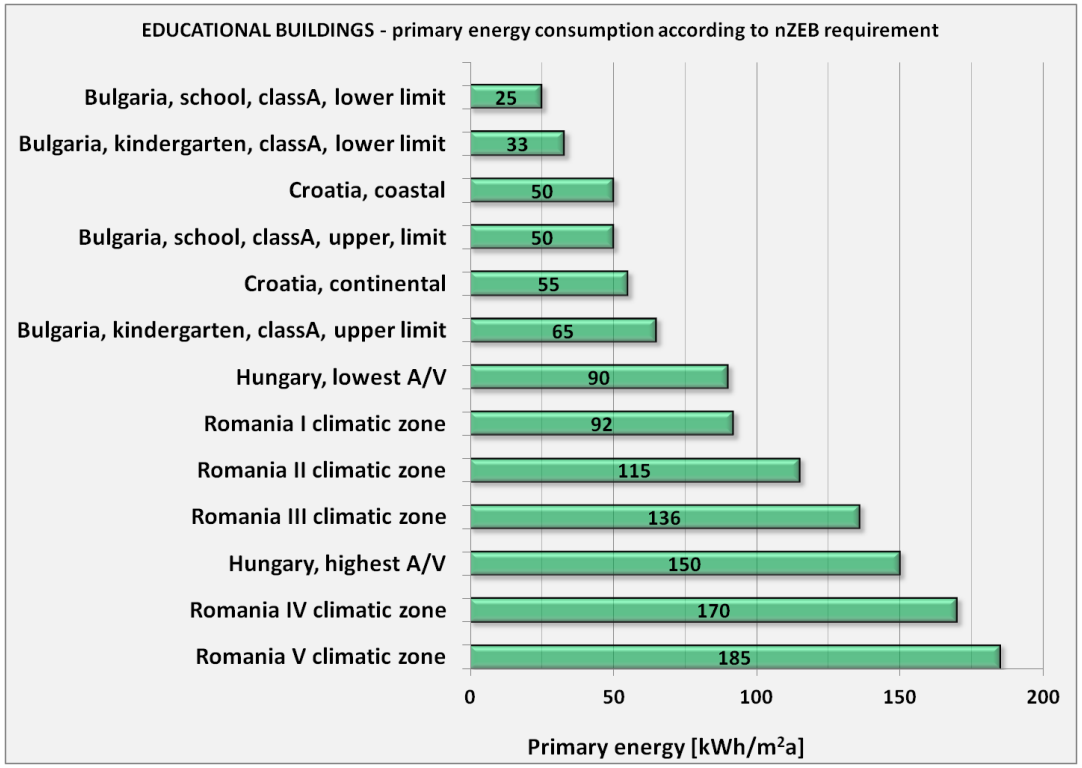
Korišteni podaci su neslužbeni podaci prikupljeni na početku projekta, te su prisutna odstupanja od naknadno definiranih zahtjeva u regulativi



Zahtjevi za zgrade gotovo nulte energije
RePublic ZEB – zgrade za edukaciju

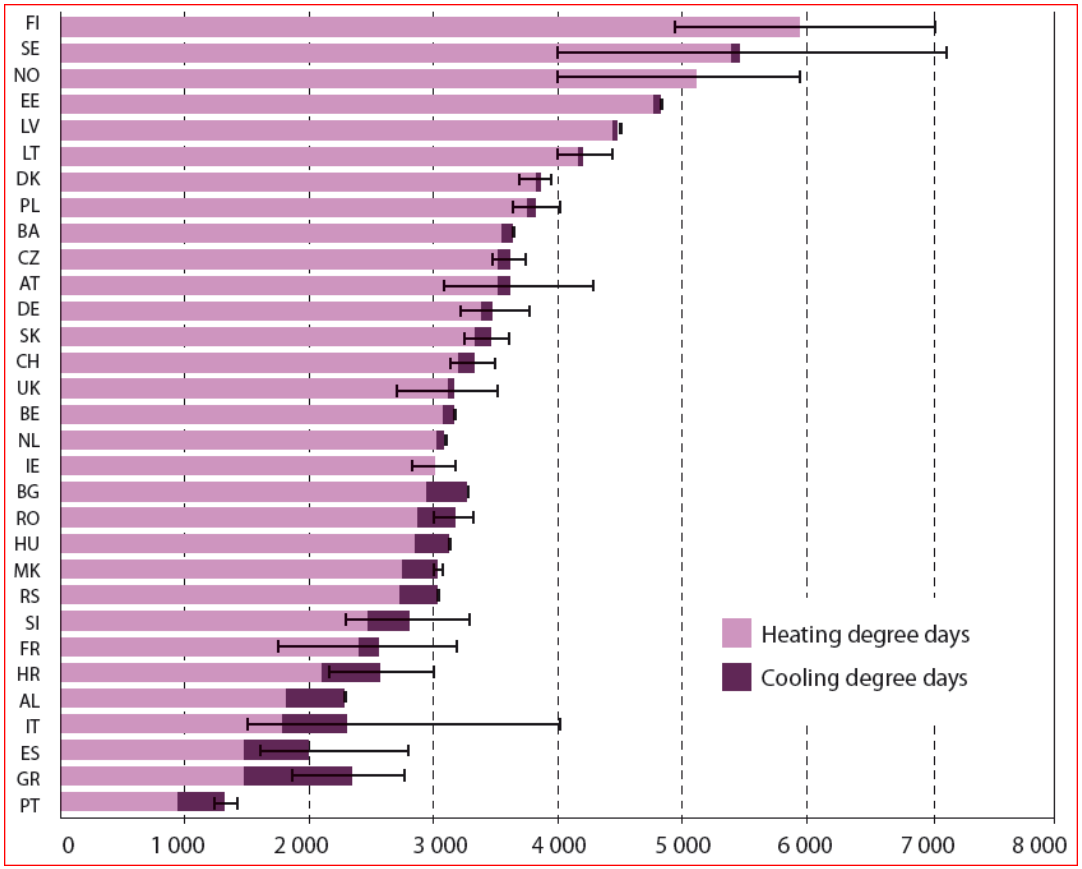
Usporedba zahtjeva za nZEB zgrade u IEE projektu RePublic_ZEB

Korišteni podaci su nesluženi podaci prikupljeni na početku projekta, te su prisutna odstupanja od naknadno definiranih zahtjeva u regulativi



Zahtjevi za zgrade gotovo nulte energije RePublic ZEB

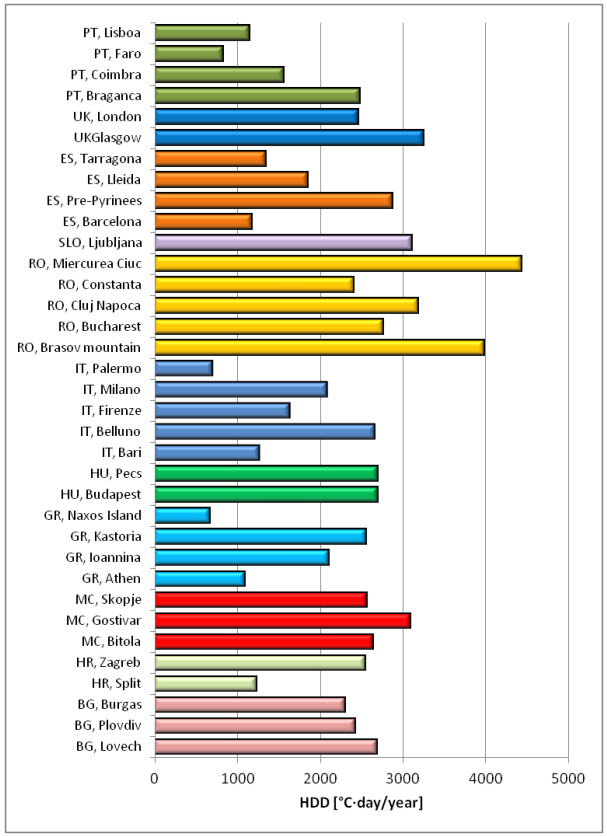
Raspon stupanj dana grijanja i hlađenja u EU vezan je uz svojstva zgrada i način korištenja, te deklarirane projektne temperature grijanja i hlađenja i nije direktno usporediv među državama. Stupanj dani grijanja pokazuju veći stupanj podudaranja od stupanj dana hlađenja



Zahtjevi za zgrade gotovo nulte energije
RePublic ZEB

Projekt pokriva područja klimatskih zona 1, 2 i 3

Usporedba stupanj dana grijanja u državama sudionicama projekta prema referentnim meteorološkim podacima



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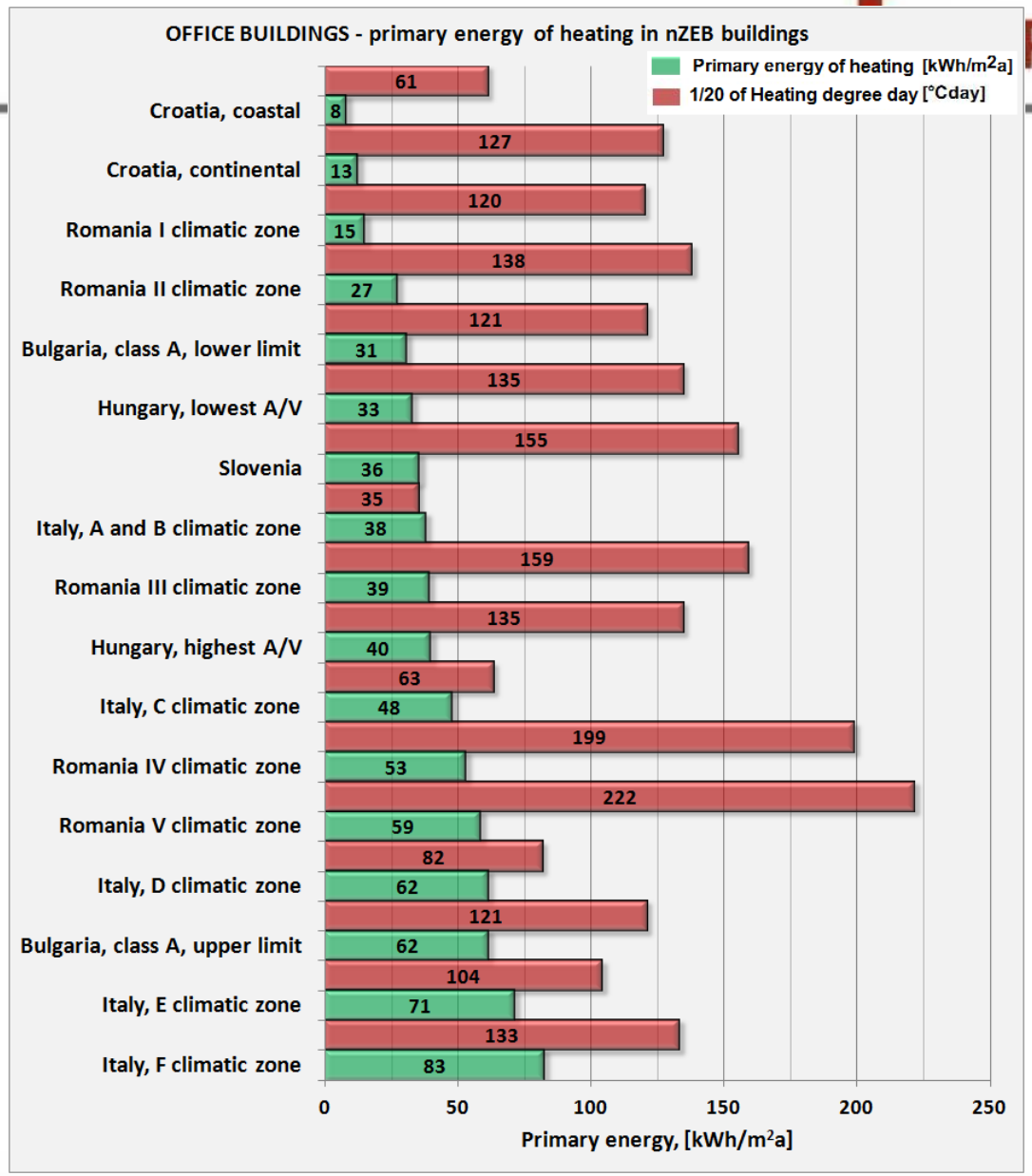
ZEROING IN ON ENERGY

Odnos primarne energije i stupanj dana grijanja

Omjerom primarne energije i stupanj dana grijanja može se uvesti usporedba zahtjeva na većem području



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ZEROING IN ON ENERGY

Raspon ekvivalentnih zahtjeva za primarnom energijom za grijanje

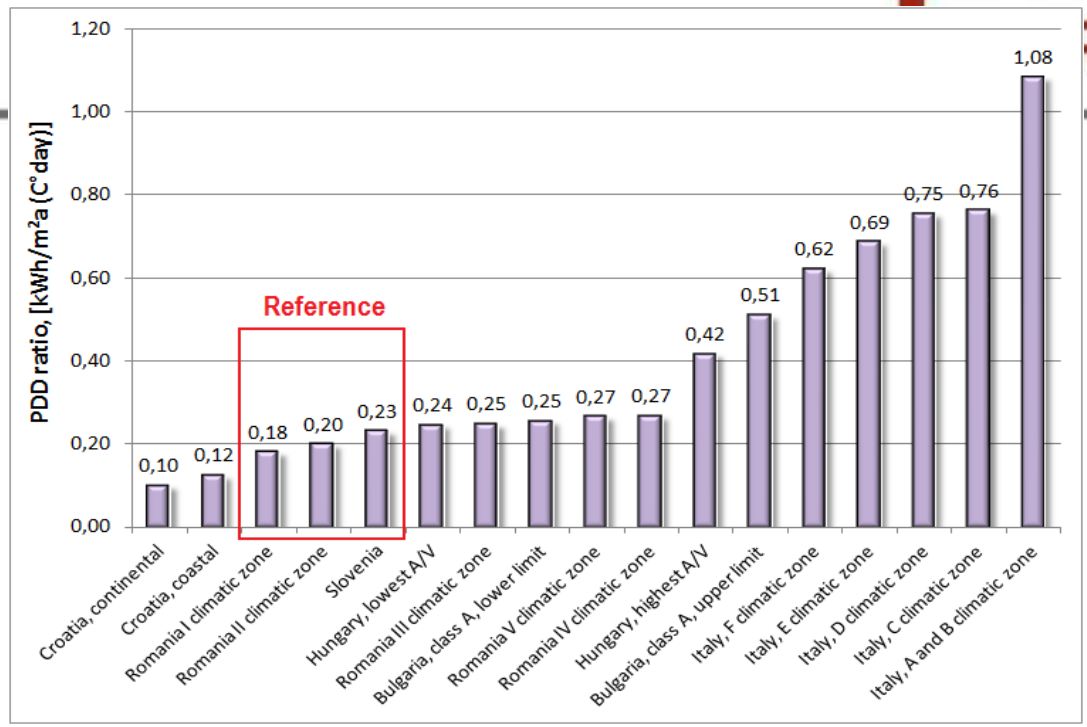
nZEB uredska zgrada:
7-44 kWh/m²a

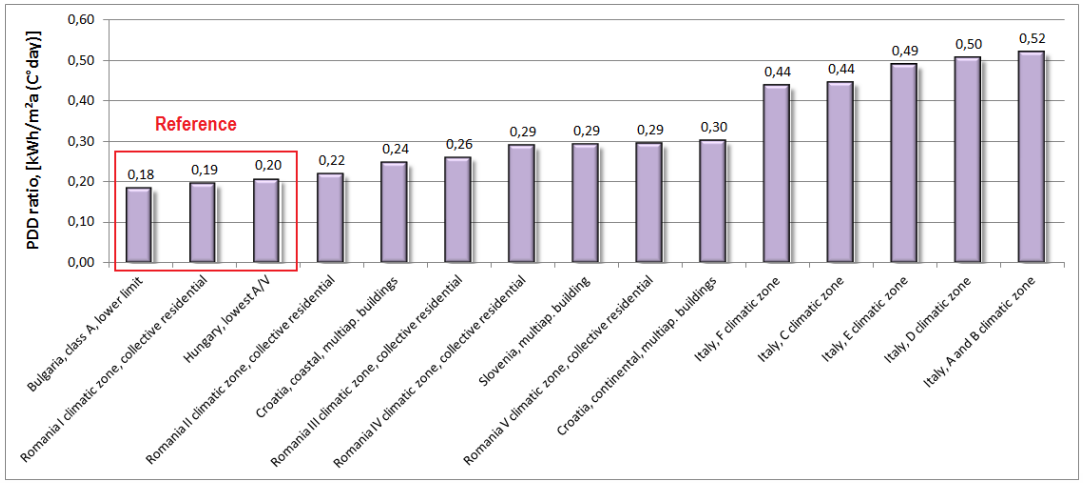
nZEB stambena zgrada:
6-42 kWh/m²a

nZEB zgrada za obrazovanje:
6-38 kWh/m²a

nZEB zgrada za zdravstvo:
11-71 kWh/m²a

Kod nestambenih zgrada, režim korištenja ima značajnu ulogu u primarnoj energiji za energetske potrebe zgrada





RePublic ZEB
ZEROING IN ON ENERGY

FIHP

Obnovljivi izvori energije za nZEB

Minimalni udio obnovljivih izvora energije u nZEB zgradama u projektu RePublic ZEB

država	Minimalni udio obnovljivih izvora energije
Italija	40%
Španjolska	40%
Portugal	40%
Grčka	35%
Slovenija	30%
Hrvatska	30%
Mađarska	25%
Bugarska	25%
Makedonija	20%
Rumunjska	15%

Troškovna optimizacija

- Zajednički alat za troškovno optimalnu kalkulaciju „Demo tool” POLITO
- Ulazni podaci:
  - meteorološki podaci
  - podaci o referentnoj zgradi

Troškovna optimizacija – meteorološki podaci

Country	Croatia
City	Zagreb
Heating degree days	2965
Winter design outside temperature	-5,0

Conditioning period by law		
	Heating	Cooling
Start	15 october	
End	15 april	

		Month											
		january	february	march	april	may	june	july	august	september	october	november	december
OUTDOOR AIR TEMPERATURE	Θ_e [°C]	1,0	2,9	7,1	11,7	16,8	20,3	21,9	21,3	16,3	11,4	6,5	1,4
MONTHLY MEAN VALUE OF THE DAILY GLOBAL SOLAR RADIATION $I_{sol,d}$ [MJ/(m²d)]	H	3,8	6,5	10,8	15,7	19,6	21,3	21,6	18,4	13,8	8,7	4,4	2,8
	N	1,6	2,6	4,0	5,5	6,7	7,1	6,9	6,0	4,5	3,1	1,9	1,3
	NE/NW	1,6	2,6	4,0	6,2	9,4	10,9	10,6	7,7	4,5	3,1	1,9	1,3
	E/W	2,8	4,9	7,7	10,6	12,8	13,7	14,0	12,4	9,9	6,5	3,2	2,0
	SE/SW	4,4	6,9	9,4	11,2	12,0	12,2	12,7	12,5	11,6	9,0	4,9	3,1
	S	5,4	8,1	9,9	10,3	10,2	10,0	10,5	10,9	11,6	10,4	6,0	3,8
	ON THE ROOF (for collectors and PV)	5,8	9,3	13,0	16,0	17,7	18,3	19,0	18,0	16,1	12,2	6,6	4,2

		Month											
		january	february	march	april	may	june	july	august	september	october	november	december
Vapor pressure	$p_{v,e}$ [Pa]	590,0	645,0	943,0	1163,0	1326,0	1840,0	1736,0	2012,0	1921,0	1412,0	958,0	671,0

Troškovna optimizacija – podaci o zgradi

BUILDING CATEGORY			Office
BUILDING ID			01
Number of thermal zones			1
BUILDING GEOMETRIC CHARACTERISTICS			
Number of units (offices, apartments…) if relevant		-	
Net floor area for each unit if relevant	$A_{f,unit}$	$[m^2]$	
Number of floors above the ground		-	2
Number of floors under the ground		-	0
Medium floor height	h	[m]	2.7
Conditioned gross volume	V_l	$[m^3]$	8032,11
Net floor area	A_f	$[m^2]$	2677,37
Envelope area	A_e	$[m^2]$	6860,8
Windows area	A_w	$[m^2]$	1022,4
A_e/A_f		-	2,56
A_w/A_f		-	0,38
A_e/V_l		-	0,85
A_w/A_e		-	0,15

Troškovna optimizacija – podaci o zoni

Thermal zone ID			1,0
Zone use			Office
THERMAL ZONE GEOMETRIC CHARACTERISTICS			
Gross floor area	$A_{f,l}$	$[m^2]$	3159
Net floor area	A_f	$[m^2]$	2677
Gross volume	V_l	$[m^3]$	10040
Net volume	V	$[m^3]$	8032
Areic internal heat capacity	κ_e	$[kJ/m^2K]$	260
DATA USERS AND OPERATING PARAMETERS			
Specific internal sensible heat gains	$\Phi_{int,mn}$	$[W/m^2]$	6
Internal latent heat gains	$G_{wv,oc}+G_{wv,A}$	[g/h]	0
Ventilation typology (Natural/Mechanical)	N/M	-	N
Time-average air flow rate	$q_{ve,mn}$	$[m^3/s]$	0,39
Temperature adjustment factor for air flow	b_{ve}	[-]	1,00
Efficiency of the heat recovery unit	η_{hru}	[-]	0,65
Temperature set point for heating	$\theta_{int,set,H}$	[°C]	20
Temperature set point for cooling	$\theta_{int,set,C}$	[°C]	26

Troškovna optimizacija – podaci o zoni

NAME	Azimuth South = 0; East = 90; West = -90 …	Tilt angle 0° = flat roof; 90° = vertical wall	Area
	Φ	Σ	A_w
	[°]	[°]	[m^2]
Window N	180	90	353
Window S	0	90	353
Window E	90	90	119
Window W	-90	90	119

Frame area fraction
Diffuse radiation shading reduction factor for external obstacles
Window thermal transmittance
Window+shutters thermal transmittance
Total solar energy transmittance of the transparent part of the element for normal solar radiation incidence
Total solar energy transmittance of the window with solar shading devices
Emissivity for infrared radiation
Shading reduction factor for external obstacles

Troškovna optimizacija – podaci o zoni

NAME Wall = W; Cavity Wall = CW; Roof = R; Ground floor = GF	Azimuth South = 0; East = 90; West = -90 …	Tilt angle 0° = flat roof; 90° = vertical wall	Area
	Φ	Σ	A_c
	[°]	[°]	[m^2]
W	180	90	487
W	0	90	1447
W	90	90	487
W	-90	90	1447
UF	0	0	1024

IF CAVITY WALL: cavity thickness
Opaque component thermal transmittance
Solar absorption
Emissivity for infrared radiation
Shading reduction factor for external obstacles

Troškovna optimizacija – podaci o zoni

NAME Wall = W; Upper floor = UF; Ground floor = GF	Heat transfer coefficient	Area	Opaque component thermal transmittance
	b_{tr}	A_c	U_c
	[-]	[m^2]	[W/m^2K]
GF	1	1024	0,52

NAME	Heat transfer coefficient	Length	Lineic thermal transmittance
	b_{tr}	l	Ψ
	[-]	[m]	[W/mK]
TM1	1	1000	0,18

Troškovna optimizacija – podaci o zoni

Thermal zone ID			1,0		
Zone use			Office		
DOMESTIC HOT WATER (DHW)					
			current building	**EEM 9**	
Volume of domestic hot water delivered	V_w	[l/day]	70		
Specified temperature of domestic hot water at tapping point	$\theta_{w,er}$	[°C]	40		
Temperature of the inlet water	$\theta_{w,0}$	[°C]	12		
DHW emission efficiency	$\eta_{w,er}$	[-]	1,00		
DHW distribution efficiency	$\eta_{w,d}$	[-]	0,89		
DHW storage (Yes/No)	-	-	no		
DHW storage heat transfer coefficient (if any)	k_{boll}	[W/K]	1,80		
DHW storage average temperature (if any)	$\theta_{avg,w,s}$	°C	60		
DHW storage environment temperature (if any)	θ_a	°C	11,55		
DHW distribution auxiliary electrical power	$P_{w,d,aux}$	[W]		40,00	
DHW geretation typology (combined/single)	-	-	combined	single	
DHW generation efficiency	$\eta_{w,g}$	[-]			
HEATING SYSTEM (H)					
			current building	**EEM 8**	**EEM 10**
H emission efficiency	$\eta_{h,er}$	[-]	0,88		
H emission auxiliary electrical power	$P_{h,er,aux}$	[W]	100		
H control efficiency	$\eta_{h,rg}$	[-]	0,82		
H distribution efficiency	$\eta_{h,d}$	[-]	0,90		
H distribution auxiliary electrical power	$P_{h,d,aux}$	[W]	100		
H pump load factor	FC	[-]	1,0		
H pump operation mode	F_V	[-]	1,0		
H generator nominal power	$\Phi_{h,Pn}$	[kW]		70	150
H generation auxiliary electrical power	$P_{h,g,aux}$	[W]		50	70
H generation efficiency	$\eta_{h,g}$	[-]			1,03
Energy carrier/Sources					
DOMESTIC HOT WATER (DHW)			ELECTRICITY		
HEATING (H)			ELECTRICITY		

Troškovna optimizacija – podaci o zoni

Thermal zone ID			1,0		
Zone use			Office		
CHILLER					
			current building	**EEM 7**	**EEM 11**
C emission efficiency	$\eta_{c,er}$	[-]	0,90	0,97	0,98
C emission auxiliary electrical power	$P_{c,er,aux}$	[W]	800	0	0
C fan speed (low/medium/high)	-	-	low	medium	high
C control efficiency	$\eta_{c,rg}$	[-]	0,95	0,98	0,98
C distribution efficiency	$\eta_{c,d}$	[-]	0,95	1,00	0,98
C distribution auxiliary electrical power	$P_{c,d,aux}$	[W]	100	0	300
C pipes lenght	$l_{c,d}$	[m]	15	8	20
C fraction of the nominal flow rate (indoor unit)	-	[%]	100	80	90
C fraction of the nominal flow rate (outdoor unit)	-	[%]	90	80	90
C storage insulation conductivity	λs	[W/mK]			
C storage surface	S	[m^2]			
C storage insulation thickness	d	[m]			
C generator nominal power	$\Phi_{c,Pn}$	[kW]	200	0	150
C Energy Efficiency Ratio	EER	[-]	2,00	3,50	
C generator auxiliary electrical power	$P_{c,d,aux}$	[W]	0	0	0
Energy carrier/Sources					
COOLING (C)			ELECTRICITY		

Troškovna optimizacija – podaci o zoni

Thermal zone ID			1,0	
Zone use			Office	
HEATING + DHW				
			current building	**EEM 11**
HP Power at full load	P_{hp}	[kW]	100	50
HP Coefficient Of Performance	COP	[-]	2,50	
HP Heating Storage insulation conductivity	λs	[W/mK]	0,04	0,04
HP Heating Storage surface	S	[m^2]	1,50	1,21
HP Heating Storage insulation thickness	d	[m]	0,06	0,06
HP DHW Storage insulation conductivity	λs	[W/mK]	0,04	0,04
HP DHW Storage surface	S	[m^2]	1,50	1,45
HP DHW Storage insulation thickness	d	[m]	0,06	0,06
Energy carrier/Sources				
HEATING + DHW			ELECTRICITY	

Troškovna optimizacija – podaci o zoni

Thermal zone ID			1,0
Zone use			Office
			JAN
Montly mean value of the daily solar radiation on the solar collectors (roof)	$I_{sol,d}$	[MJ/m^{2}d]	6
Solar collectors end use (DHW/H/DHW+H)	-	-	DHW
Solar collectors area	A	[m^2]	0,00
Solar collectors typology	-	-	
DHW storage volume (if any)	V_{nom}	[l]	
DHW storage heat transfer coefficient (if any)	k_{boll}	[W/K]	
Temperature correction coefficient for the storage room	b_{tr}	[-]	
Energy carrier/Sources			
SOLAR COLLECTORS			THERMAL ENERGY FROM SOLAR COLLECTORS

Troškovna optimizacija – podaci o zoni

Thermal zone ID	1,0
Zone use	Office

			JAN
Montly mean value of the daily solar radiation on the solar collectors (roof)	$I_{sol,d}$	[MJ/m^{2}d]	6

PV peak power	W_{pv}	[kW]	
PV panels ventilation	-	-	
Energy carrier/Sources			
PV			ELECTRICITY FROM PV

Troškovna optimizacija – podaci o zoni

Thermal zone ID			1,0
Zone use			Office
LIGHTING			
Lighting power density	P_n	[W/m^2]	10
Daylight dependent artificial lighting control	$F_{D,C}$	[-]	1,00
Lighting control factor	F_{OC}	[-]	1,00

Troškovna optimizacija – podaci o zoni

Calculation time	**20**
Evaluation type (1: financial; 2: macroeconomic)	**1**
Real interest rate	**6%**
VAT	25%

BUILDING COMPONENTS	Maintenance [%]	Disposal [%]	Lifespan
External wall thermal insulation	4%	0%	20
Cavity wall thermal insulatio	4%	0%	20
Roof/Upper floor	4%	0%	20
Ground floor	4%	0%	20
Window thermal insulation	4%	0%	20
Solar shading systems	4%	0%	20

BUILDING TECHNICAL SYSTEMS	Maintenance [%]	Disposal [%]	Lifespan
Chiller	4%	0%	15
boiler	2%	0%	20
heat pump	4%	0%	15
radiator	2%	0%	35
radiant panels	2%	20%	50
fancoil	4%	0%	15
Solar collectors	1,0%	0%	20
PV panels	1,0%	0%	20
Recovery ventilation system	4,0%	0%	20
Lighting EEL 1	2,5%	0%	15
Lighting EEL 2	1,3%	0%	15
Lighting EEL 3	2,0%	0%	15
Lighting EEL 4	0,6%	0%	15

HVAC + Lighting Electrical power installed [kW]	40
Additional Electrical power installed for air conditioning after refurbishment	10

Troškovna optimizacija – podaci o zoni

ENERGY NEED			
Energy need for heating	$Q_{H,nd}$	[kWh/m^{2}a]	**103**
Energy need for cooling	$Q_{C,nd}$	[kWh/m^{2}a]	**21**
Energy need for DHW	$Q_{W,nd}$	[kWh/m^{2}a]	**0**

ENERGY DEMAND [kWh]					
Energy carrier/Sources	**HEATING**	**COOLING**	**DHW**	**VENTILATION**	**LIGHTING**
NATURAL GAS	382422	0	0	0	0
GAS OIL	0	0	0	0	0
LPG	0	0	0	0	0
WOOD	0	0	0	0	0
ELECTRICITY	703	43624	876	0	77304
DISTRICT HEATING	0	0	0	0	0
THERMAL ENERGY FROM SOLAR COLLECTORS	0	0	0	0	0
ELECTRICITY FROM PV	0	0	0	0	0
THERMAL ENERGY FROM OUTDOORS (FREE COOLING)	0	0	0	0	0
THERMAL ENERGY FROM OUTDOORS (HEAT PUMPS)	43976	0	-25	0	0

CROATIA			
Primary energy factors			
Energy carrier/Sources	**nren**	**ren**	**tot**
NATURAL GAS	1,1	0,0	1,1
GAS OIL	1,2	0,0	1,2
LPG	1,2	0,0	1,2
WOOD	0,1	1,0	1,1
ELECTRICITY	0,8	0,8	1,6
DISTRICT HEATING	1,5	0,0	1,5
THERMAL ENERGY FROM SOLAR COLLECTORS	0,0	1,0	1,0
ELECTRICITY FROM PV	0,0	1,0	1,0
THERMAL ENERGY FROM OUTDOORS (FREE COOLING)	0,0	1,0	1,0
THERMAL ENERGY FROM OUTDOORS (HEAT PUMPS)	0,0	1,0	1,0

Troškovna optimizacija – početni rezultati

PRIMARY ENERGY					
	Symbol	**Unit**	**nren**	**ren**	**tot**
Energy Performance for HEATING	EP_H	[kWh/m^{2}a]	157	17	174
Energy Performance for COOLING	EP_C	[kWh/m^{2}a]	13	13	26
Energy Performance for DHW	EP_W	[kWh/m^{2}a]	0	0	1
Energy Performance for VENTILATION	EP_V	[kWh/m^{2}a]	0	0	0
Energy Performance for LIGHTING	EP_L	[kWh/m^{2}a]	23	24	47
Global Energy Performance	EP_{gl}	[kWh/m^{2}a]	**193**	**54**	**247**

PV SYSTEM			
Electricity from PV exported	$E_{el,pv,exp}$	[kWh]	0

RENEVABLE SOURCES			
Renewable Energy Ratio	RER	[%]	**22%**

Troškovna optimizacija – usporedba referentnog troška i varijanti

N. of EEM
17

Start Optimization

N.	EEM (inglese)	N. parameters	Parameter (inglese)	Symbol	No. EEO	Level of EEO 1	2	3	4	5	Level of EEO 1	2	3	4	5	
						Parameter values					Cost of EEM					
1	External wall thermal insulation (EIFS-EW): exterior insulation finishing system	1	Thermal transmittance	U_p	5	0,56	0,34	0,29	0,25	0,2	37,07	42,47	46,28	50,42	57,94	€/m^2
2	External wall thermal insulation (CWI-EW): cavity wall insulation	1	Thermal transmittance	U_p	2	0,50	0,35				23,67	28,07				€/m^2
3	Roof thermal insulation (INS-R)	1	Thermal transmittance	U_r	5	0,4	0,3	0,27	0,23	0,2	19	25	28	33	38	€/m^2
4	Floor thermal insulation (INS-F)	1	Thermal transmittance	U_f	5	0,45	0,33	0,29	0,24	0,2	24	31	35	41	48	€/m^2
5	Window thermal insulation	1	Thermal transmittance	U_w	5	5	2,2	1,9	1,6	1,3	215	363	371	382	435	€/m^2
6	Solar shading systems (SHAD): 1 fix; 2 movable	1			2	1	2				40	105				€/m^2
7	High efficiency chiller (CHIL)	1	Energy efficiency ratio at design conditions	EER	3	3,5	4	5			10080	12600	15120			€
8	High efficiency generator for space heating (GHS)	1	Generator efficiency at design conditions	η_{gn}	3	0,88	0,934	1,03			3250	3700	7100			€
9	High efficiency generator for DHW (HES-DHW)	1	Generator efficiency at design conditions	$\eta_{gn,Pn,W}$	3	0,88	0,934	1,03			1600	2000	3200			€
10	High efficiency combined generator for space heating and hot water	1	Generator efficiency at design conditions	η_{gn}	3	0,88	0,934	1,03			3750	4300	8400			€
11	Heat pump for heating, cooling and hot water	2	Coefficient of performance at design conditions	COP	3	2,3	2,7	3,1			19125	22575	24875			€
			Energy efficiency ratio at design conditions	EER		2,1	2,5	2,9								
12	Thermal solar systems (SOL)	1	Surface of solar collectors	m^2	3	2	4	6			1600	3000	5000			€
13	PV system (PV)	1	Peak power	kWp	4	3	5	8	10		9000	15000	24000	30000		€
14	Heat recovery ventilation system (ERVS)	1	Heat recovery efficiency	η_r	3	0,6	0,7	0,9			9600	12000	14400			€
15	Improving Control System (ICS)	1	Control efficiency	η_{ctr}	0	0,94	0,97	0,995			INCLUDED	INCLUDED	INCLUDED			
16	Lighting power density (LPD)	1	Specific luminaire power (W/m^2) (UNI EN 15193)	PN	4	1	2	3	4		25	29,8	36,15	45,25		€/m^2
17	Lighting control systems (LCS)	1	Occupancy dependency factor (and constant illuminance factor) (UNI EN 15193)	F_O (F_C)	0	13 1 (1) T5 no reg	13 0,9 (0,9) T5 with reg	4,7 1 (1) LED no reg	4,6 0,8 (0,9) LED with reg							
14	Heat recovery ventilation system (ERVS)	Volume flow rate	V_{vent}	[l/s]	-	83	77	66								

Troškovna optimizacija – usporedba referentnog troška i varijanti

Reference Global Cost	Optimal Global Cost	Test Global Cost
[€]	[€]	[€]
€ 353.276	€ 294.137	€ 294.137

Test Cost of EEM
[€]
€ 45.236

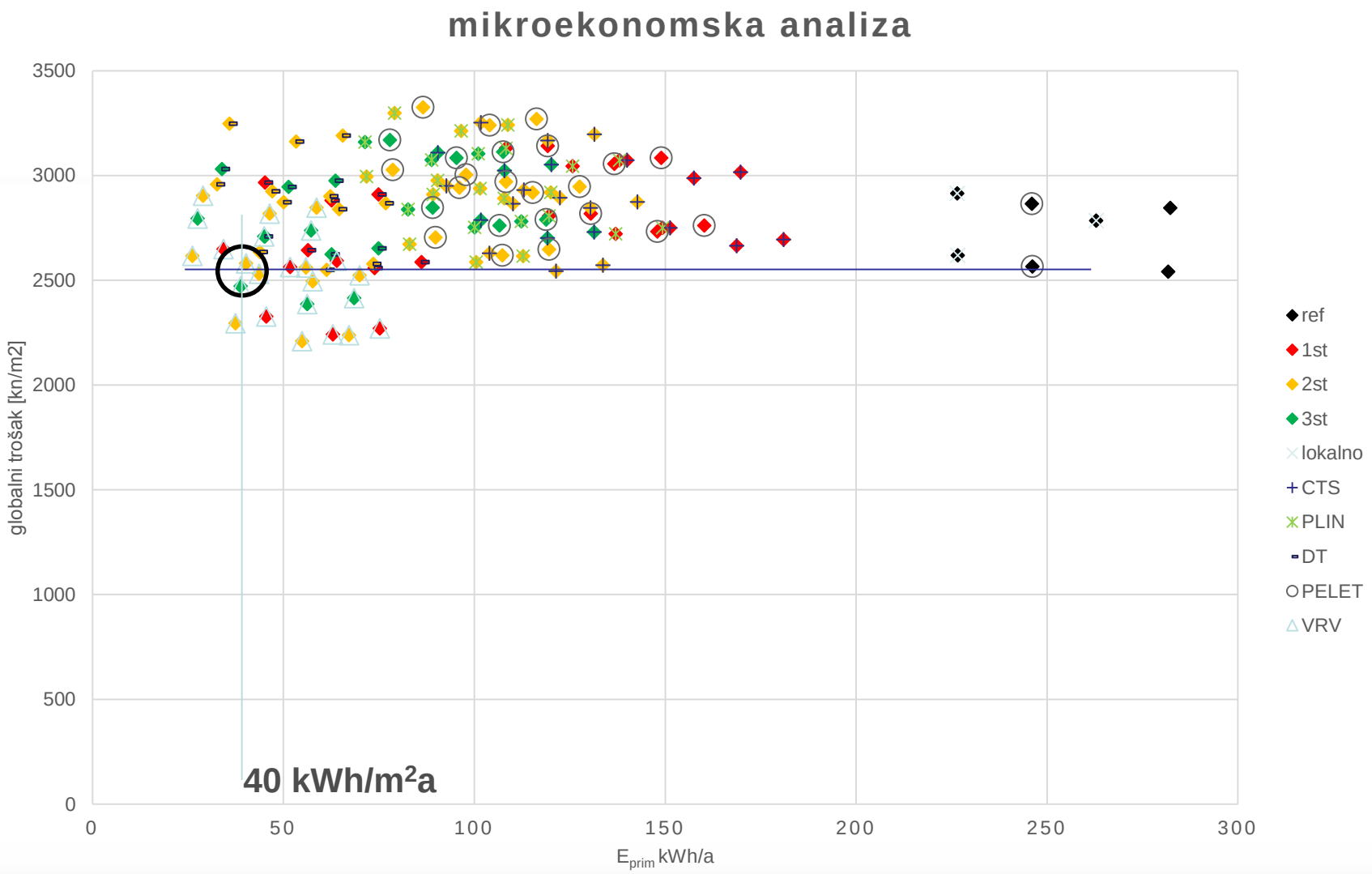
EEO				
Reference	Optimum	Test	Parameter value	Cost of EEM
1	0	0		0
0	2	2	0,35	28,07
2	2	2	0,3	25,45
3	3	3	0,29	34,94482759
4	4	4	1,6	382
1	1	1	1	40
0	1	1	3,5	10080
0	0	0		0
0	0	0		0
0	3	3	1,03	8400
3	0	0		0
3	1	1	2	1600
4	2	2	5	15000
1	1	1	0,6	9600
0	0	0		0
3	4	4	4	45,25
0	0	0		

Trenutni zahtjevi

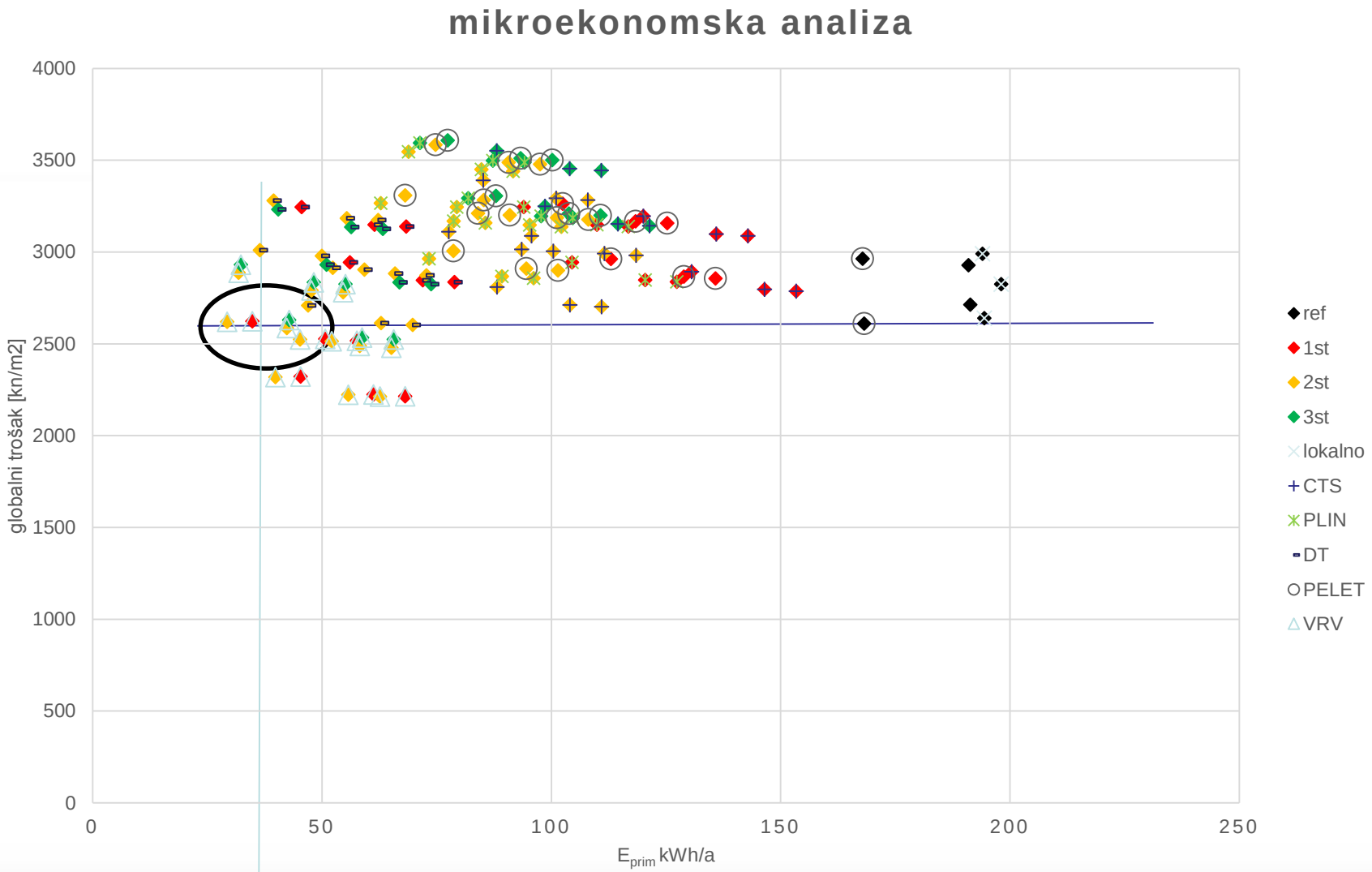
ZAHTJEVI ZA NOVE ZGRADE i G0EZ	$Q''_{H,nd}$ [kWh/(m²·a)]						E_{prim} [kWh/(m²·a)]				E_{del} [kWh/(m²·a)]	
	NOVA ZGRADA i G0EZ						NOVA		G0EZ		NOVA	
KATEGORIJA ZGRADE	kontinent, $\theta_{mm} \leq 3$ °C			primorje, $\theta_{mm} > 3$ °C			kont $\theta_{mm} \leq 3$ °C	prim $\theta_{mm} > 3$ °C	kont $\theta_{mm} \leq 3$ °C	prim $\theta_{mm} > 3$ °C	kont $\theta_{mm} \leq 3$ °C	prim $\theta_{mm} > 3$ °C
	$f_0 \leq 0{,}20$	$0{,}20 < f_0 < 1{,}05$	$f_0 \geq 1{,}05$	$f_0 \leq 0{,}20$	$0{,}20 < f_0 < 1{,}05$	$f_0 \geq 1{,}05$						
Višestambena	40,50	$32{,}39 + 40{,}58 \cdot f_0$	75,00	24,84	$19{,}86 + 24{,}89 \cdot f_0$	45,99	120	90	80	50	80	60
Obiteljska kuća	40,50	$32{,}39 + 40{,}58 \cdot f_0$	75,00	24,84	$17{,}16 + 38{,}42 \cdot f_0$	57,50	115	70	45	35	80	50
Uredska	16,94	$8{,}82 + 40{,}58 \cdot f_0$	51,43	16,19	$11{,}21 + 24{,}89 \cdot f_0$	37,34	70	70	35 40	25 30	40	40
Obrazovna	11,98	$3{,}86 + 40{,}58 \cdot f_0$	46,48	9,95	$4{,}97 + 24{,}91 \cdot f_0$	31,13	65	60	55 40	55 40	60	60
Bolnica	18,72	$10{,}61 + 40{,}58 \cdot f_0$	53,21	46,44	$41{,}46 + 24{,}89 \cdot f_0$	67,60	300	300	250	250	220	220
Hotel i restoran	35,48	$27{,}37 + 40{,}58 \cdot f_0$	69,98	11,50	$6{,}52 + 24{,}89 \cdot f_0$	32,65	130	80	90	70	90	50
Sportska dvorana	96,39	$88{,}28 + 40{,}58 \cdot f_0$	130,89	37,64	$32{,}66 + 24{,}91 \cdot f_0$	58,82	400	170	210	150	290	110
Trgovina	48,91	$40{,}79 + 40{,}58 \cdot f_0$	83,40	13,90	$8{,}92 + 24{,}91 \cdot f_0$	35,08	450	280	170	150	290	170
Ostale nestambene	40,50	$32{,}39 + 40{,}58 \cdot f_0$	75,00	24,84	$19{,}86 + 24{,}89 \cdot f_0$	45,99	150	100	/	/	80	60

ZAHTJEVI – RE-KONSTRUKCIJA	$Q''_{H,nd}$ [kWh/(m²·a)]						E_{prim} [kWh/(m²·a)]		E_{del} [kWh/(m²·a)]	
	kontinent, $\theta_{mm} \leq 3$ °C			primorje, $\theta_{mm} > 3$ °C			kontinent $\theta_{mm} \leq 3$ °C	primorje $\theta_{mm} > 3$ °C	kontinent $\theta_{mm} \leq 3$ °C	primorje $\theta_{mm} > 3$ °C
KATEGORIJA ZGRADE	$f_0 \leq 0{,}20$	$0{,}20 < f_0 < 1{,}05$	$f_0 \geq 1{,}05$	$f_0 \leq 0{,}20$	$0{,}20 < f_0 < 1{,}05$	$f_0 \geq 1{,}05$				
Višestambena	50,63	$40{,}49 + 50{,}73 \cdot f_0$	93,75	27,00	$21{,}59 + 27{,}06 \cdot f_0$	50,00	180	130	120	85
Obiteljska kuća	50,63	$40{,}49 + 50{,}73 \cdot f_0$	93,75	27,00	$19{,}24 + 38{,}82 \cdot f_0$	60,00	135	80	120	60
Uredska	21,18	$11{,}03 + 50{,}73 \cdot f_0$	64,29	17,60	$12{,}19 + 27{,}06 \cdot f_0$	40,60	75	75	40	40
Obrazovna	14,98	$4{,}84 + 50{,}73 \cdot f_0$	58,10	10,81	$5{,}40 + 27{,}06 \cdot f_0$	33,83	90	75	60	60
Bolnica	23,40	$13{,}26 + 50{,}73 \cdot f_0$	66,51	50,48	$45{,}06 + 27{,}06 \cdot f_0$	73,48	340	330	250	230
Hotel i restoran	44,35	$34{,}21 + 50{,}73 \cdot f_0$	87,48	12,50	$7{,}09 + 27{,}06 \cdot f_0$	35,50	145	115	90	80
Sportska dvorana	120,49	$110{,}35 + 50{,}73 \cdot f_0$	163,61	40,91	$35{,}50 + 27{,}06 \cdot f_0$	63,93	420	215	295	190
Trgovina	61,14	$50{,}99 + 50{,}73 \cdot f_0$	104,25	15,11	$9{,}71 + 27{,}06 \cdot f_0$	38,13	475	300	290	185
Ostale nestambene	50,63	$40{,}49 + 50{,}73 \cdot f_0$	93,75	27,00	$21{,}59 + 27{,}06 \cdot f_0$	50,00	180	130	/	/

Uredska prije 1970. kontinent

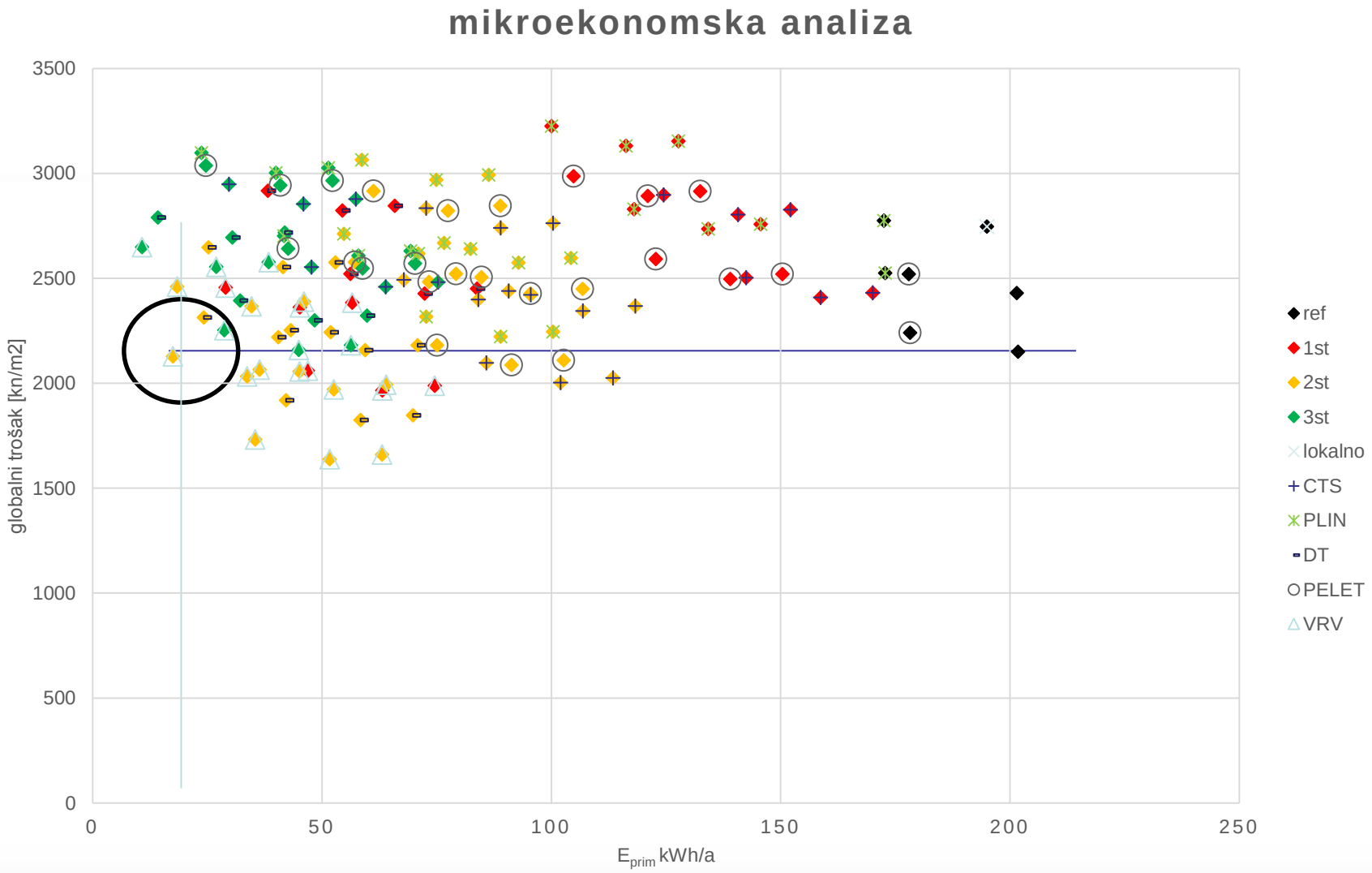


Uredska 1971. – 2005. kontinent



30 kWh/m²a

Uredska prije 1970. primorska



20 kWh/m²a

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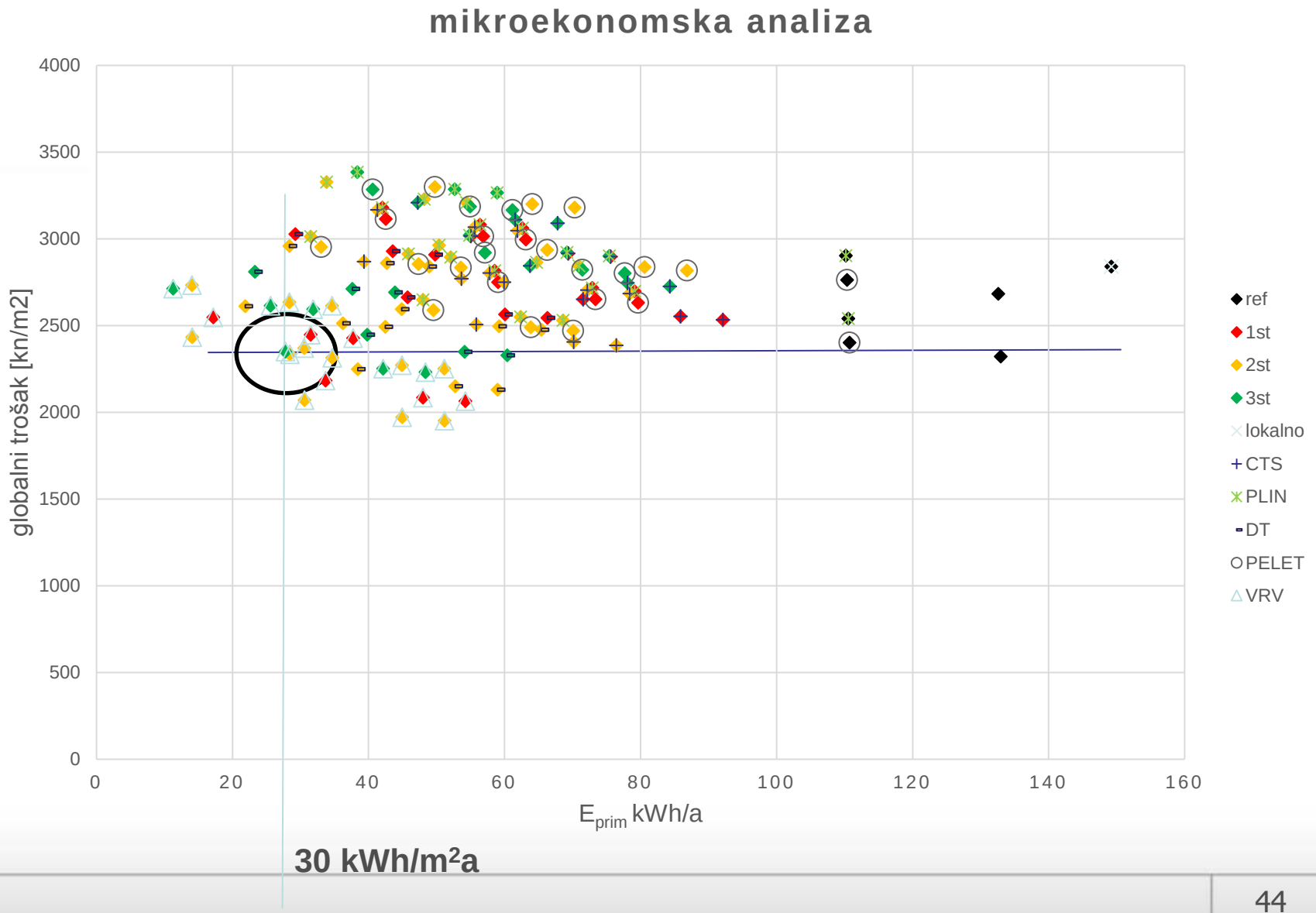

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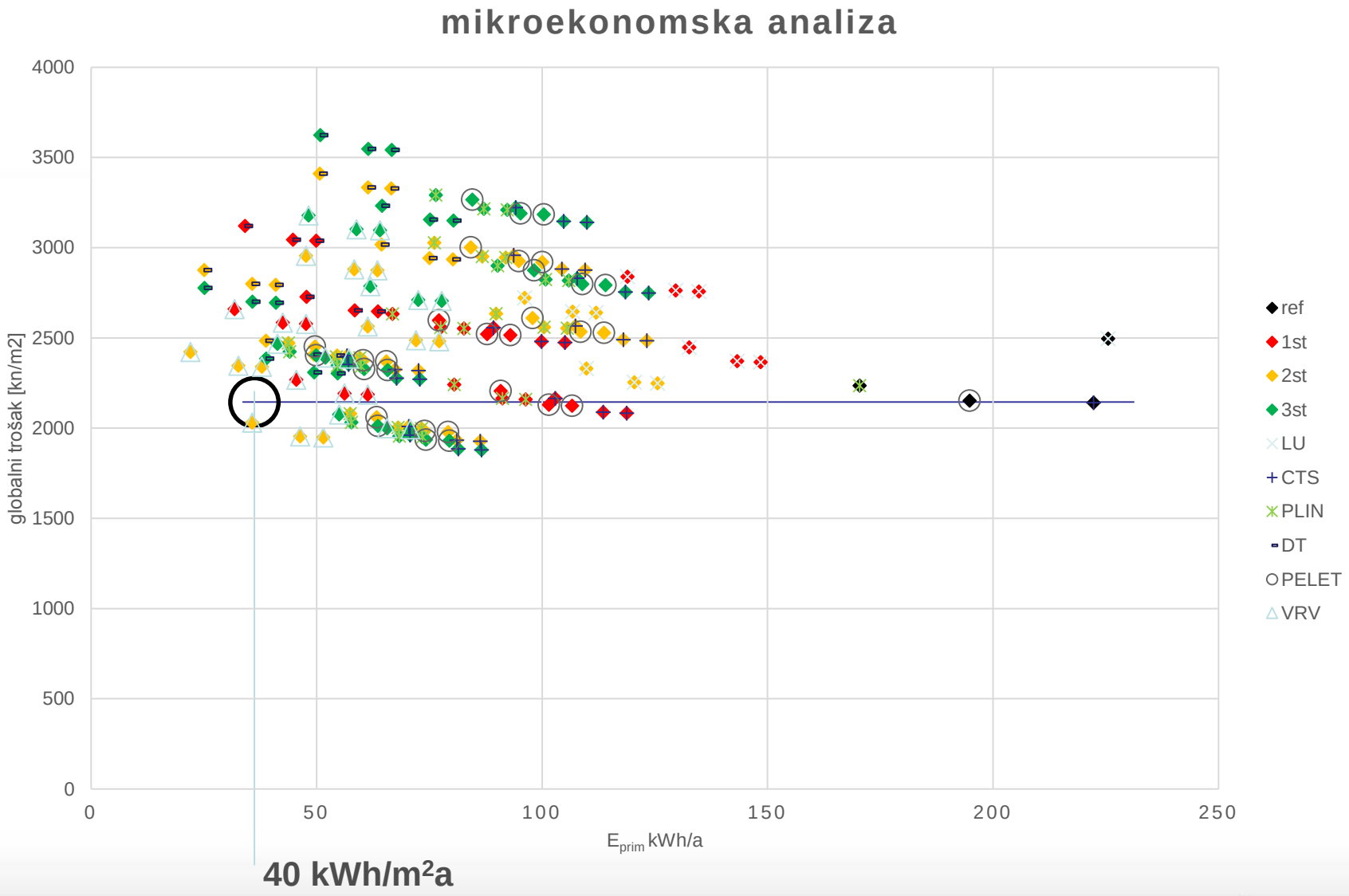
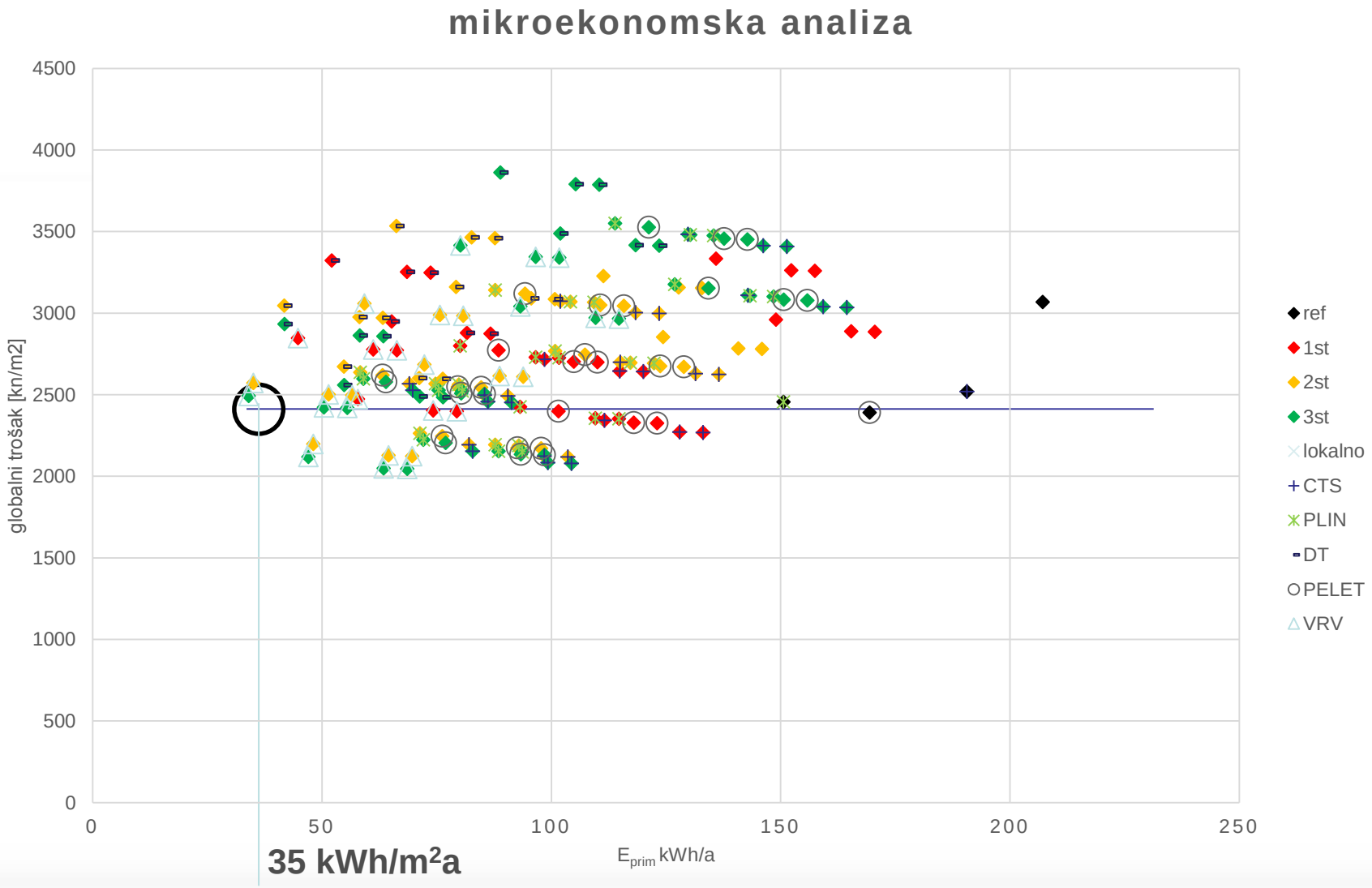


Obrazovanje 1971-2005 kontinent



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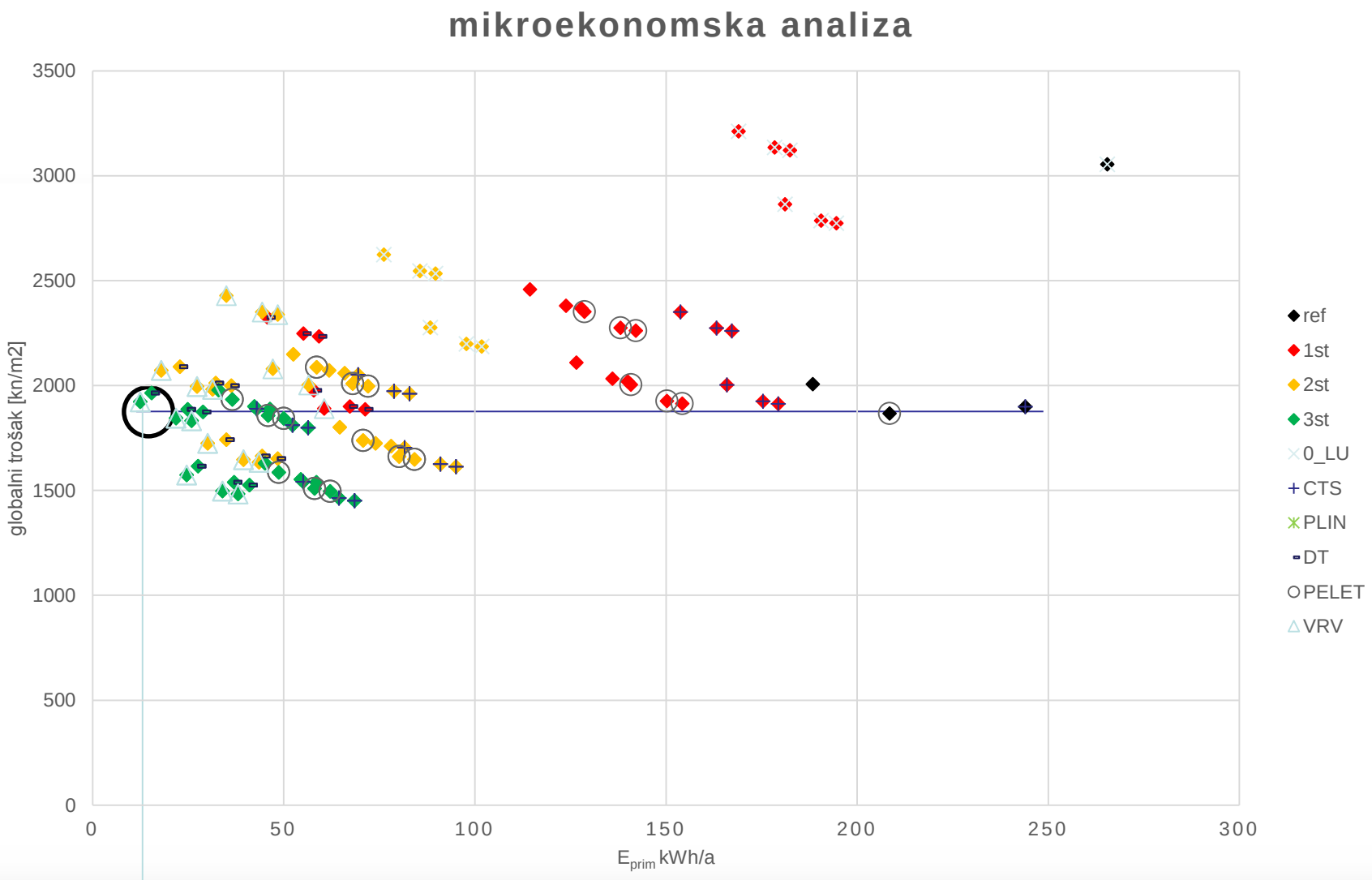
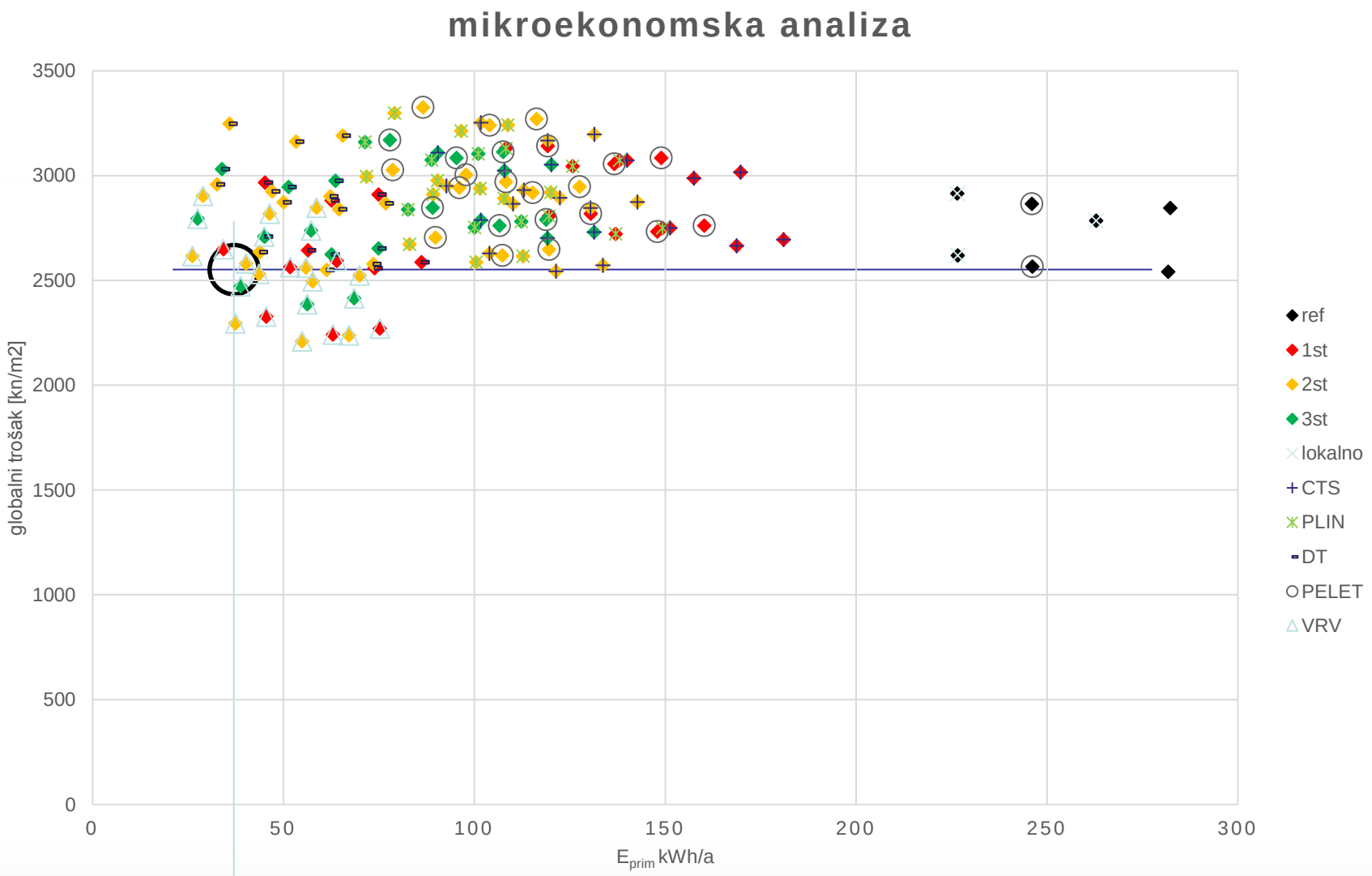


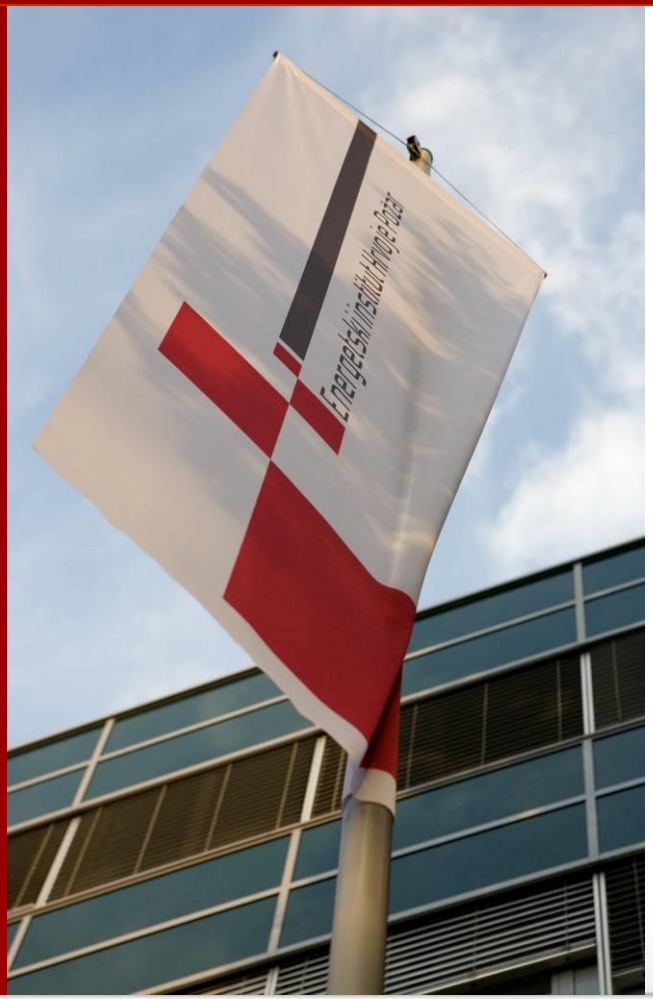
15 kWh/m²a

Obrazovanje 1971-2005 primorska



40 kWh/m²a

Hvala na pozornosti!



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