Montenegro
Ministry of Capital Investments

njemačka saradnja
DEUTSCHE ZUSAMMENARBEIT

KFW

Fraunhofer IBP

Cost-optimal study and recommendations for notional buildings

Simon Woessner, Fraunhofer IBP

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32nd Energy Efficiency Coordination Group Meeting – 23.06.2023

EPC - STATUS IN MONTENEGRO

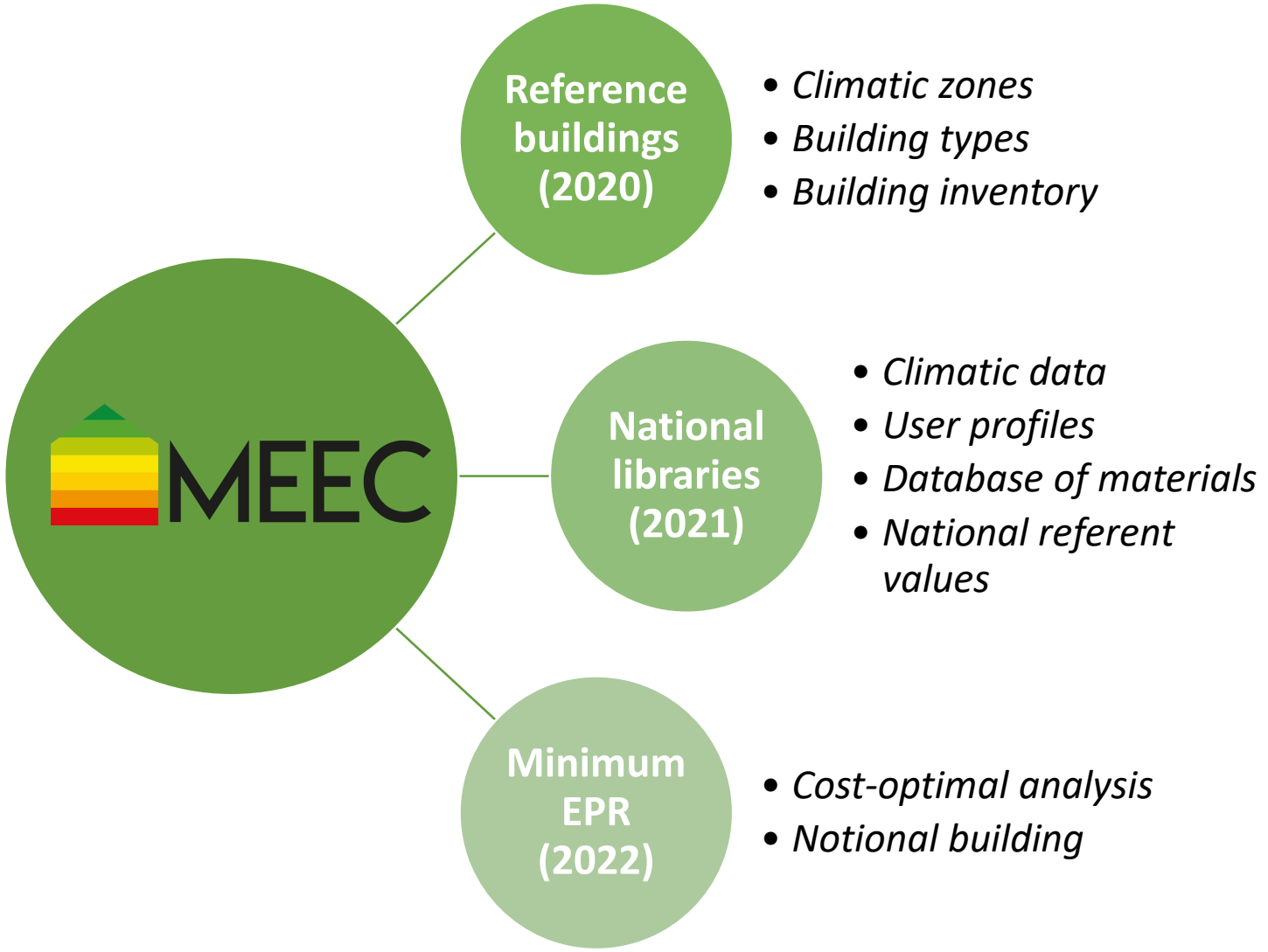
- Ministry of Capital investments is responsible for overall energy efficiency policy including setting up the national framework for energy performance certification in buildings.
- From 2013 Montenegro has set **minimum energy performance requirements** which implementation was **controlled only during design phase** of the building. Evaluation of building energy performance after construction/major renovation was not performed do to the **lack of EPC tool**.

EPC - STATUS IN MONTENEGRO

- Support for setting up national EPC scheme was provided by KfW bank within the project „Promotion of energy Efficiency in Public Buildings (PEEPB)“ which supported implementation of several activities:
  - Establishment of **inventory of buildings** and definition of **reference buildings**;
  - Preparation of national **energy performance calculation methodology** and development of **EPC software (MEEC)**;
  - Development of **Cost-optimal Study** for setting up new energy performance requirements.
- New national framework for energy performance in buildings will be based on the results of the above activities. Remaining step is adoption of the rulebooks which will reflect findings of the cost-optimal study and make new EPRs obligatory during building construction/renovation.

DEVELOPMENT OF EPC TOOL

- Work on development of the national EPC software - MEEC (*Montenegrin Energy Efficiency Certification*) has started back in 2020 in cooperation with Fraunhofer IBP (Stuttgart, Germany).



Source: dena

DIRECTIVE 2010/31/EU of 19 May 2010 on the energy performance of buildings

Incorporated and adapted by Ministerial Council Decision 2010/02/MC-EnC of 24 September 2010 amending Decision 2009/05/MC-EnC of 18 December 2009 on the implementation of certain Directives on Energy Efficiency.

The adaptations made by Ministerial Council Decision 2010/02/MC-EnC are highlighted in **bold and blue**.

Whereas:

(1) Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings has been amended. Since further substantive amendments are to be made, it should b

(2) An efficient, prudent

Article 4

Setting of minimum energy performance requirements

1. **Contracting Parties** shall take the necessary measures to ensure that minimum energy performance requirements for buildings or building units are set with a view to achieving cost-optimal levels. The energy performance shall be calculated in accordance with the methodology referred to in Article 3. Cost-optimal levels shall be calculated in accordance with the comparative methodology framework referred to in Article 5 once the framework is in place.

Contracting Parties shall take the necessary measures to ensure that minimum energy performance requirements are set for building elements that form part of the building envelope and that have a significant impact on the energy performance of the building envelope when they are replaced or retrofitted, with a view to achieving cost-optimal levels.

Calculation and variations – Buildings and technical systems

		Only columns with a name are considered.		
Building name		B1	B2	B3
Residential/Nonresidential building?	-	Residential	Residential	Residential
Reference building type	-	Multi family home	Multi family home	Multi family home
Number of residential units	-	6	10	20
Number of heated storeys	-	3	5	5
Mean storey height (heated storeys)	-	3,2	2,8	3,1
Wall area south (without windows)	m²	95,40	159,69	199,86
Wall area west (without windows)	m²	104,25	26,94	183,49
Wall area north (without windows)				
Wall area east (without windows or total wall area v				
Control: Wall area				
Window area south				
Window area west				
Window area north				
Window area east				
Window area horizontal				
Control: Window area				
Control: WWR or fw				
Wall to unheated rooms				
Wall to unheated basement rooms				
Wall to unheated attic				
Area lower completion - Basement Ceiling				
Area lower completion - to outside air				
Area lower completion - Floor slab				
Control: Lower completion				

	A	B	C	I	J	K	L
1							
2	**HVAC description**			**Biomass /underfloor**	**Wood chips /radiators**	**Wood chips /underfloor**	**HP gro**
3	Heating	Generator	-	Condensing boilers with radiators	Wood chips boiler with	Wood chips boiler with	Ground s heat pum
4		Energy carrier	-	Gas			
5	Hot water	Type	-	Central with circulatic			
6							

	A	B	C	D	E
				Only columns with a name are considered.	
	HVAC description			**Light_CFL_Man**	**Light_CFL_Pr**
	Lighting	Luminaire	-	Energy savers (CFLs)	Energy savers
		Control	-	Manual control	Presence det in circulatior and restro

Calculation and variations – Building envelope

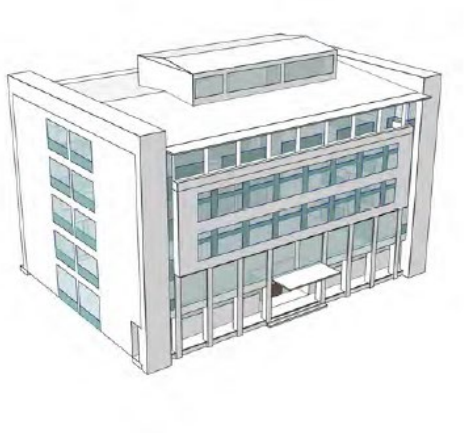
B	C	D	E	F	G	H	I
		Only columns with a name are considered.					
Building envelope		**25% above**	**Rulebook**	**Step 1**	**Step 2**	**Step 3**	**Step 4**
U-Value: External walls, walls to the garage, walls to the attic	W/(m²·K)	0,75	0,60	0,50	0,40	0,30	0,20
U-Value: Windows, balcony doors, roof windows, transparent façade elements	W/(m²·K)	2,50	2,00	1,90	1,80	1,60	1,40
U-Value: Flat and pitched roofs above heat space, ceilings towards the attic	W/(m²·K)	0,50	0,40	0,30	0,25	0,20	0,15
U-Value: Ceilings beyond external air, ceilings beyond garages	W/(m²·K)	0,50	0,40	0,30	0,25	0,20	0,15
U-Value: Walls and ceilings towards the non-heated rooms, non-heated stairs of temperature above 0 °C, rooms that are ocassionally used and areas of other purpose	W/(m²·K)	0,80	0,65	0,55	0,50	0,40	0,35
U-Value: Walls to the ground, floors on the ground	W/(m²·K)	0,65	0,50	0,40	0,35	0,40	0,35
U-Value: Exterior doors, doors towards non-heated stairs, doors with opaque wing	W/(m²·K)	2,90	2,90	2,90	1,80	1,80	1,80
g-Value window	-	0,70	0,60	0,60	0,60	0,60	0,50
gtot for fw < 0,4	-	gtot·fw < 0.20	gtot·fw < 0.20	gtot·fw < 0.20	gtot·fw < 0.20	gtot·fw < 0.20	gtot·fw < 0.20
g_tot for fw > 0,4		0,50	0,50	0,50	0,50	0,50	0,50

Calculation and variations – Szenario data

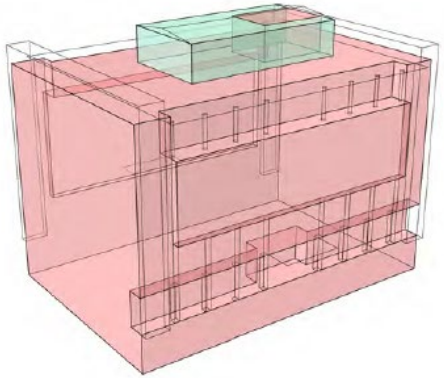
Name of scenario		Base	Double energy prices	Base price (more recent)	Double energy prices (more recent)
Fueloil	-				
Baseprice	€	0,00	0,00	0,00	0,00
Consumption price per kWh	€/kWh	0,136	0,272	0,169	0,338
Price development	%/a	2,00	2,00	2,00	2,00
LPG	-				
Baseprice	€	0,00	0,00	0,00	0,00
Consumption price per kWh	€/kWh	0,130	0,260	0,147	0,294
Price development	%/a	2,00	2,00	2,00	2,00
Pellets	-				
Baseprice	€				
Consumption price per kWh	€/kWh	0,04	0,080	0,067	0,134
Price development	%	2,00	2,00	2,00	2,00
Electricity	-				
Baseprice	€				
Consumption price per kWh	€/kWh	0,110	0,220	0,120	0,240
Price development	%	2,00	2,00	2,00	2,00

Typical Buildings

C3



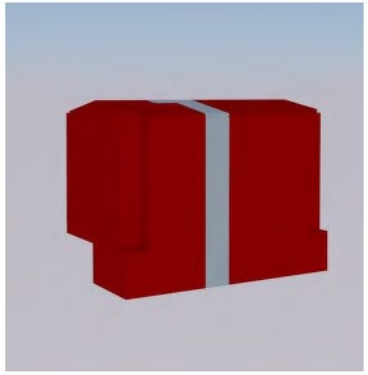
IZGLED ZGRADE



ODNOS GREJANIH / NEGREJANIH VOLUMENA

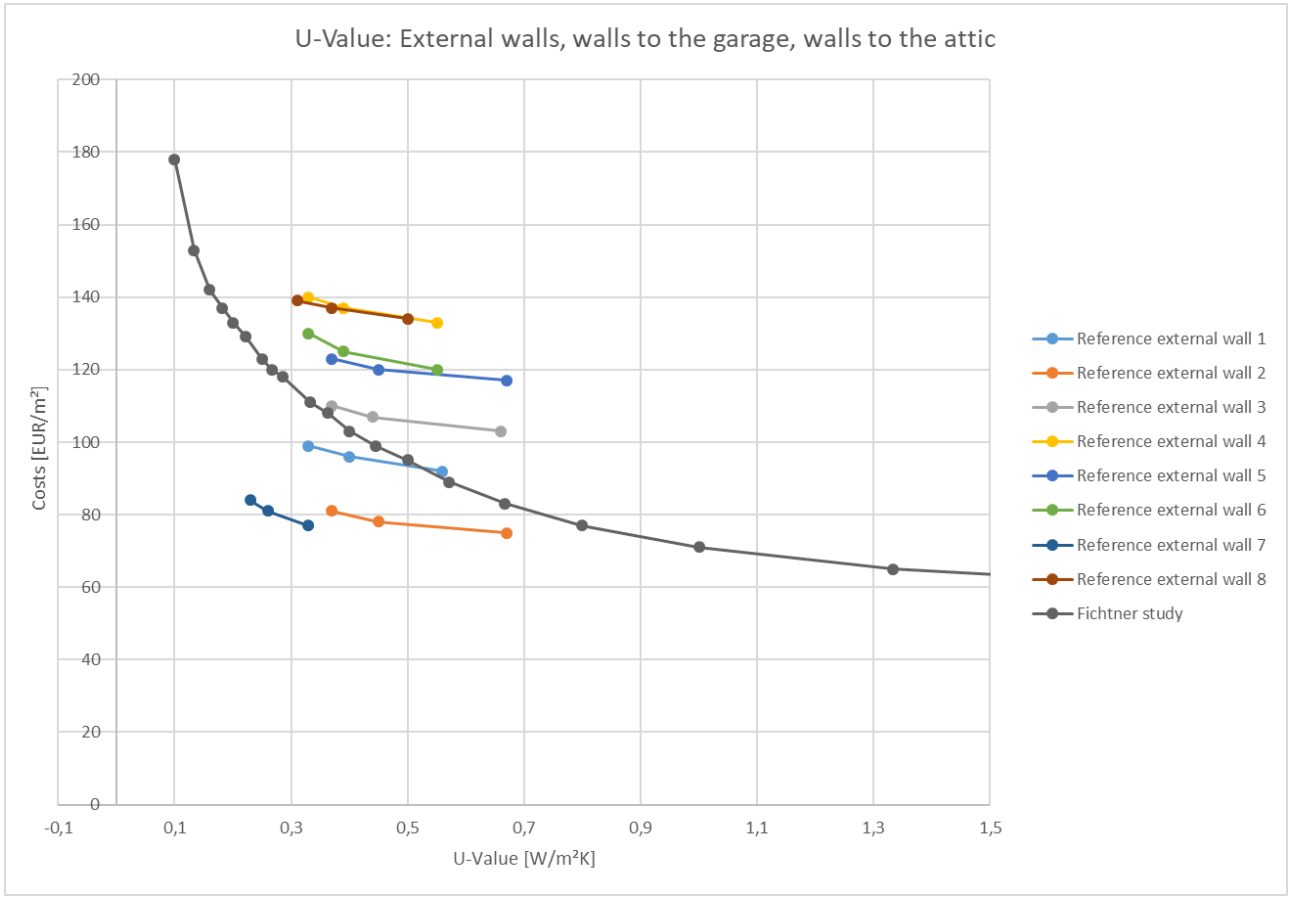
B3

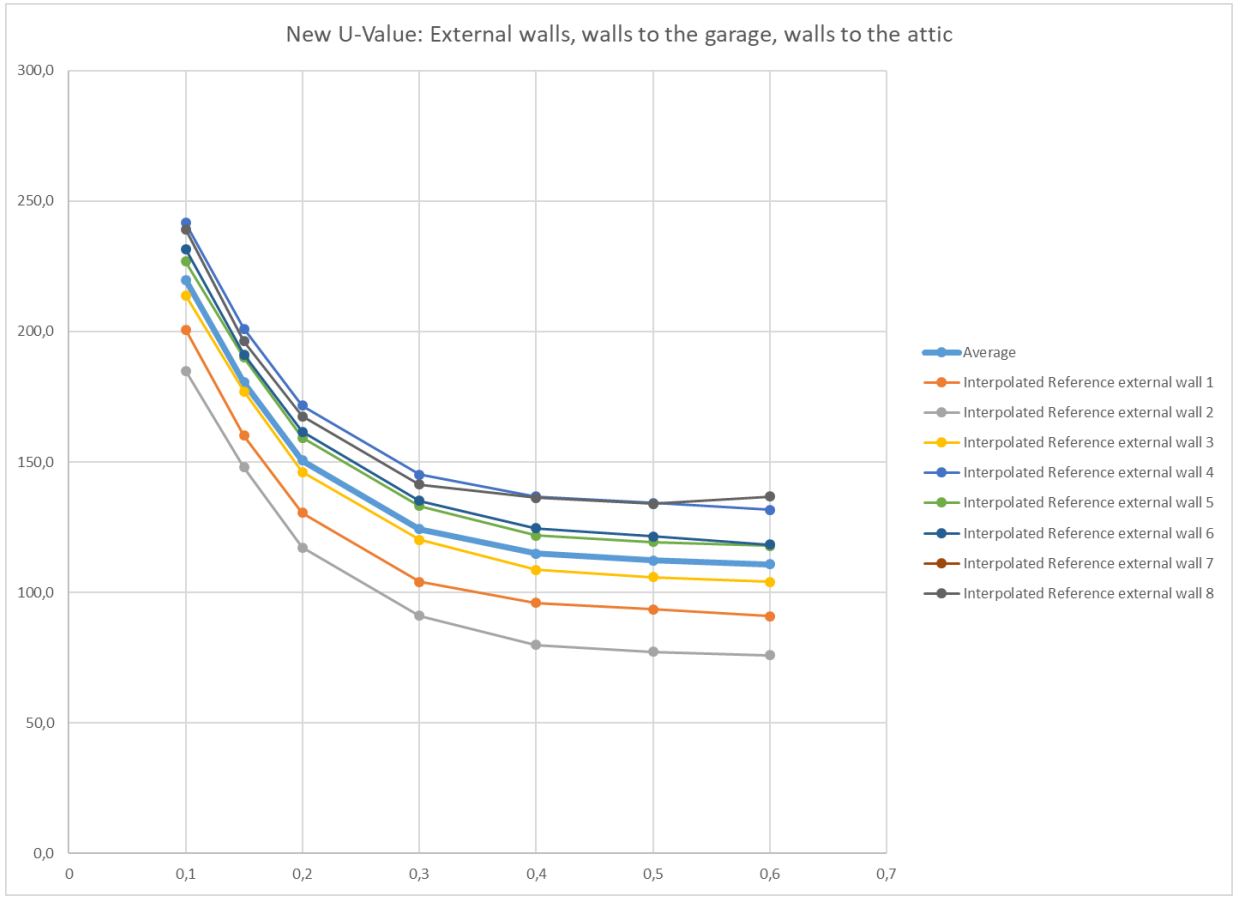
IZGLED ZGRADE

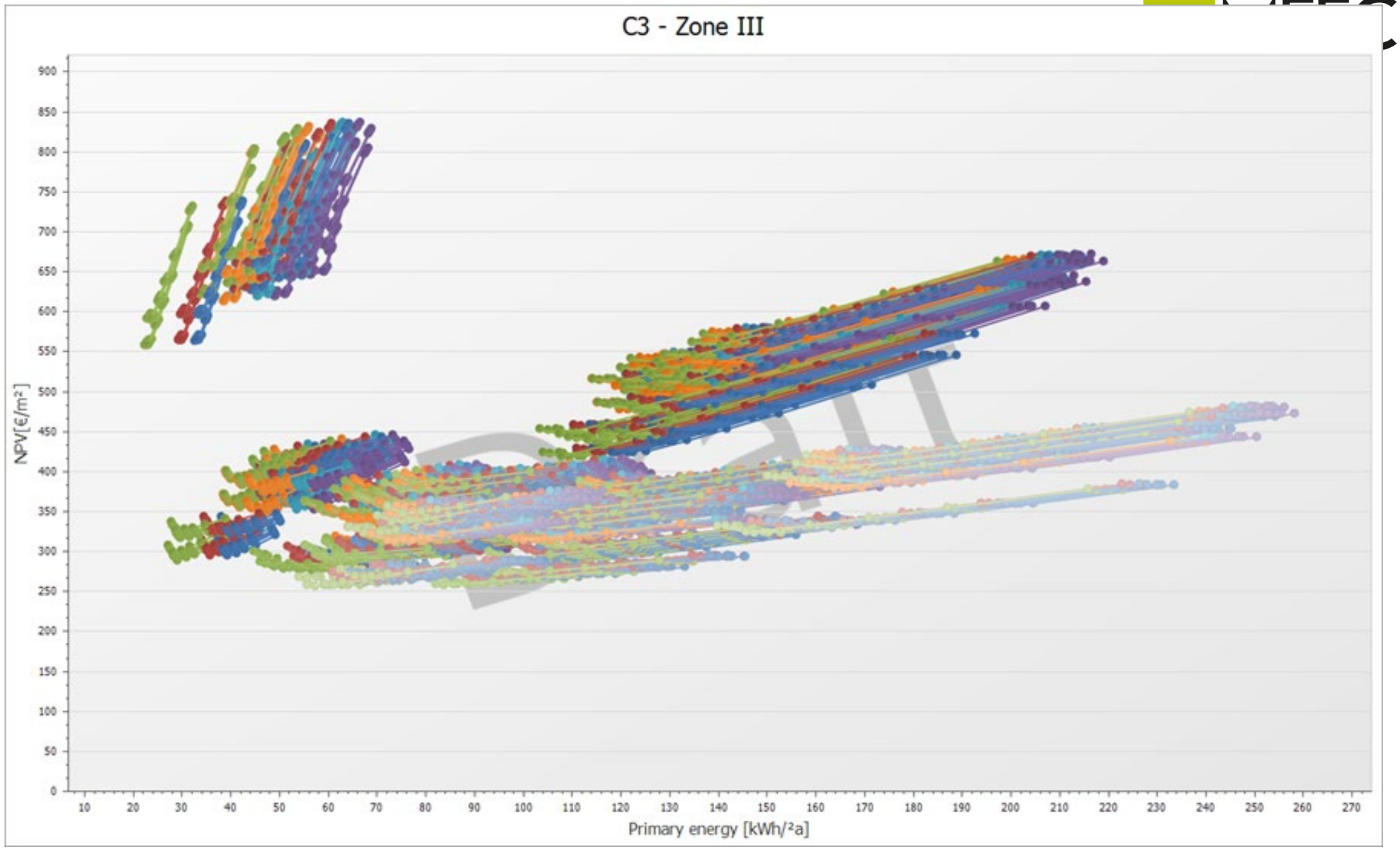


ODNOS GREJANIH / NEGREJANIH VOLUMENA

Cost Database – external walls






C3 - Zone III
NPV[€/m²]
Primary energy [kWh/²a]
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
10
20
30
40
50
60
70
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250
260
270

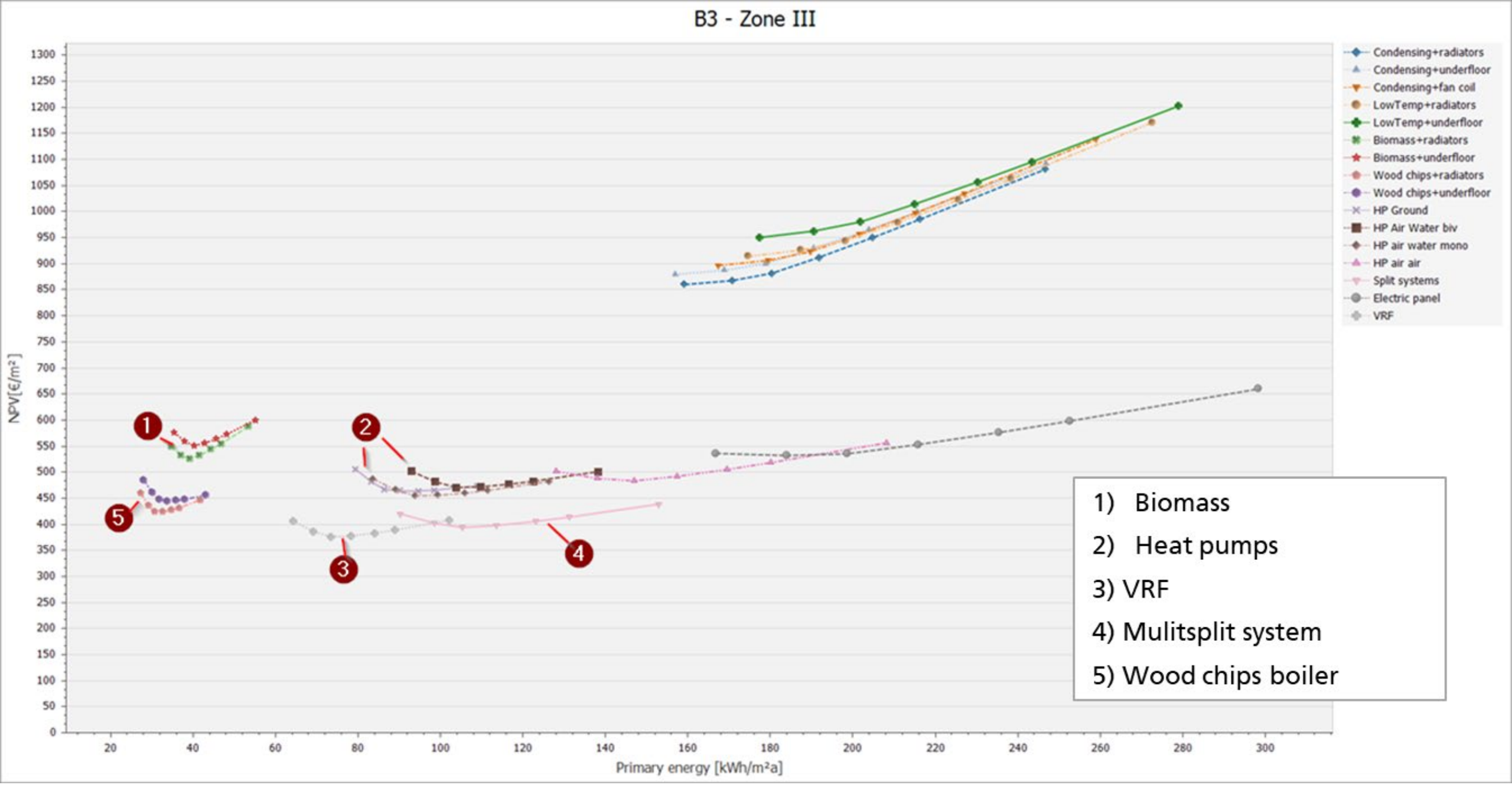
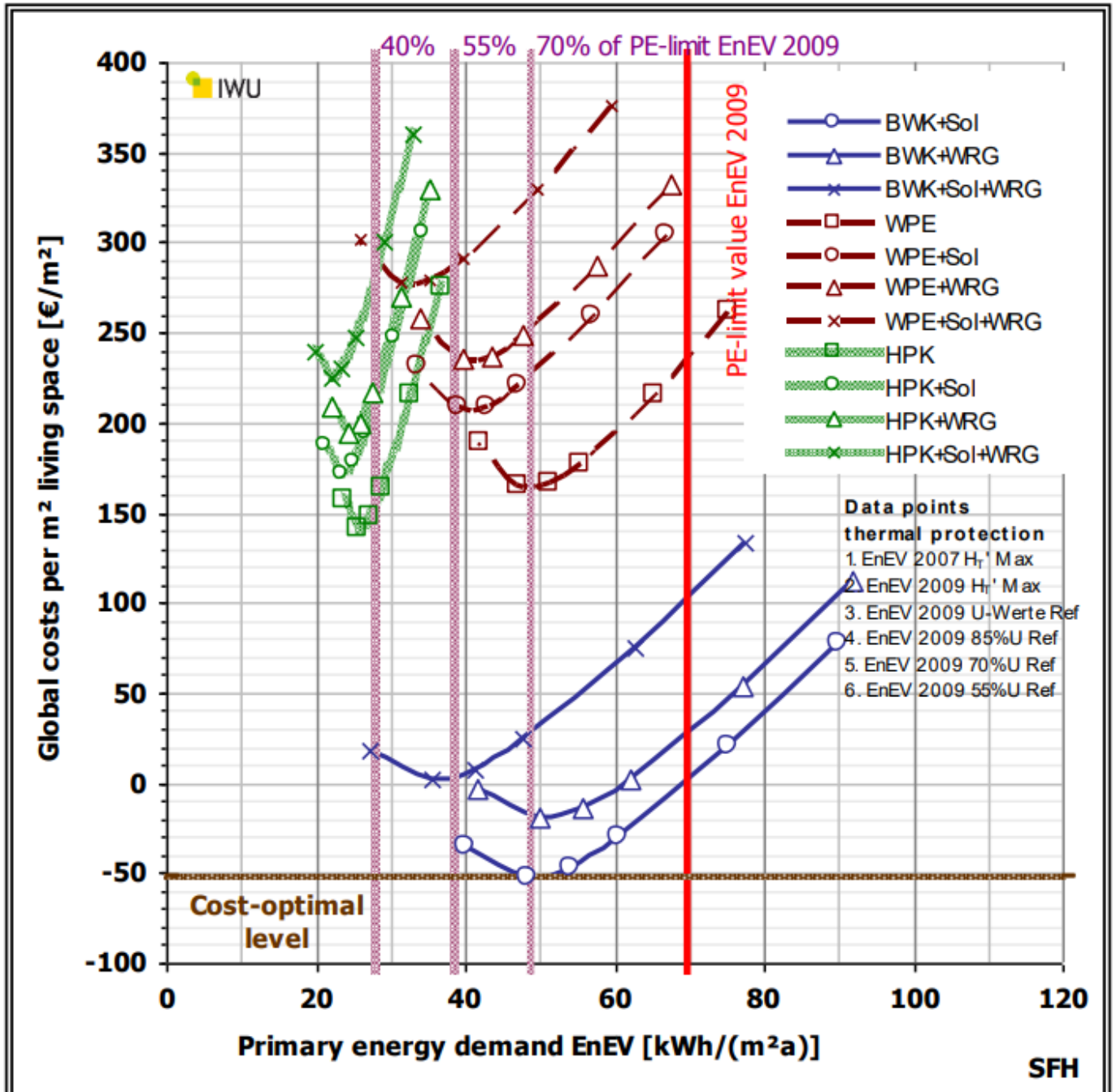

B3 - Zone III
NPV[€/m²]
Primary energy [kWh/m²a]
Condensing+radiators
Condensing+underfloor
Condensing+fan coil
LowTemp+radiators
LowTemp+underfloor
Biomass+radiators
Biomass+underfloor
Wood chips+radiators
Wood chips+underfloor
HP Ground
HP Air Water biv
HP air water mono
HP air air
Split systems
Electric panel
VRF
1) Biomass
2) Heat pumps
3) VRF
4) Mulitsplit system
5) Wood chips boiler

Fig. 8: Global costs SFH / all heat supply systems (high energy price development/discount rate 1 %)



No transferable results!!!

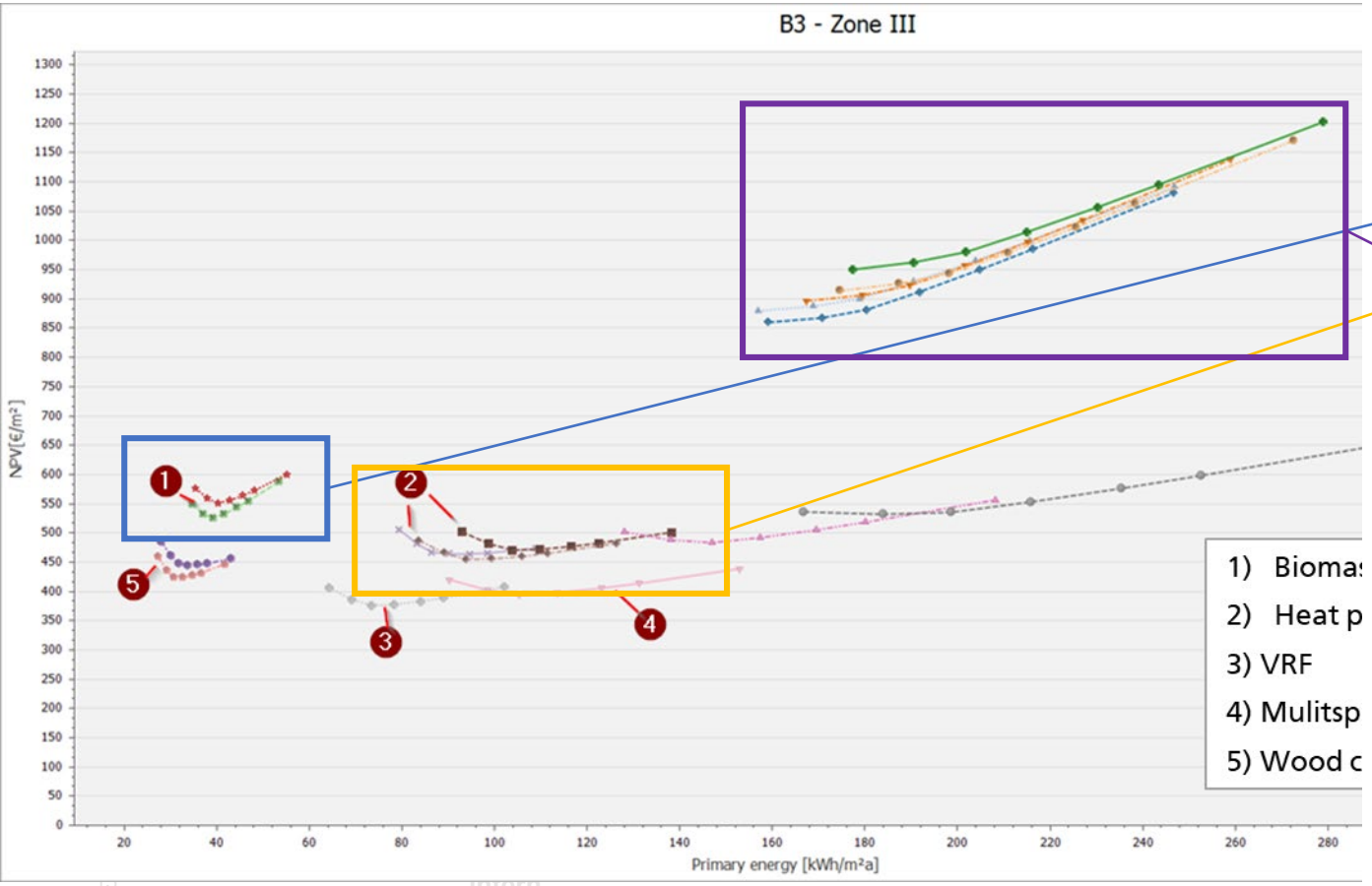
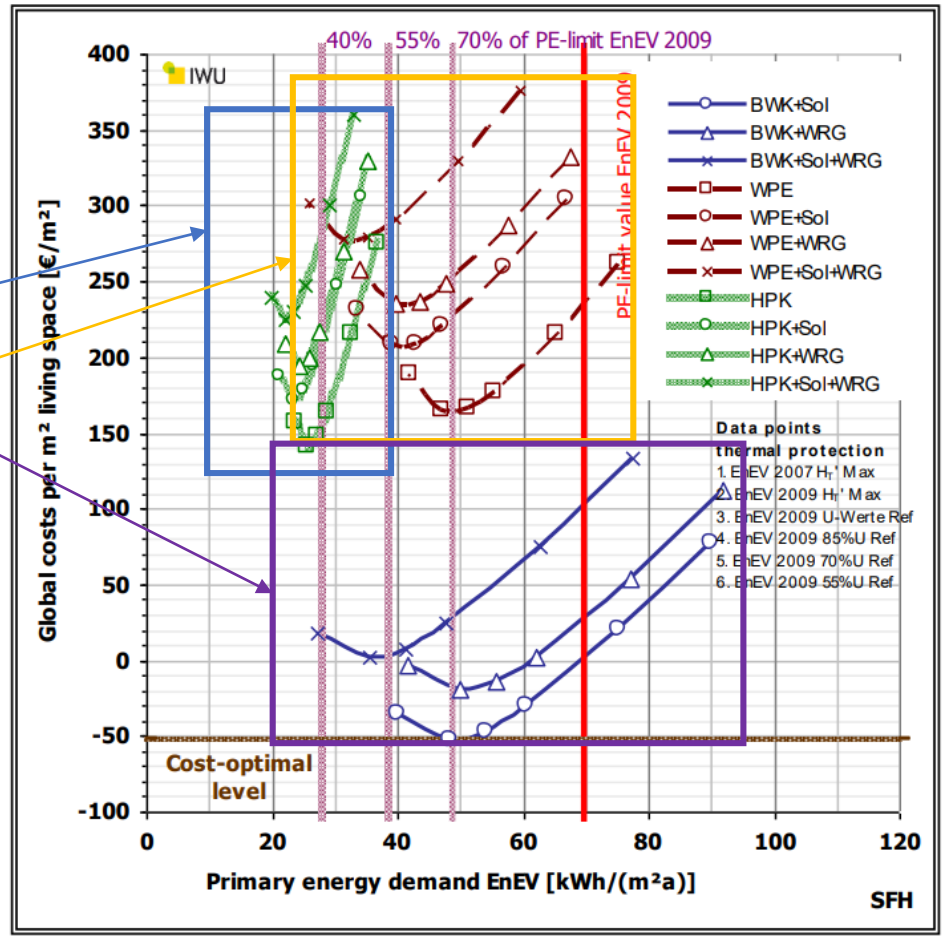


Fig. 8: Global costs SFH / all heat supply systems (high energy price development/discount rate 1 %)



Cost optimal study is only the first step

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Institutsleitung

Prof. Dr. Philip Leistner

IBP-Report 003/2023/750 – Revision 2

Cost-optimal Study

Montenegro

Conducted for
Ministry of Capital Investments, Directorate for Energy and Energy Efficiency

The report has:
150 pages of text
141 figures

Authors:
Simon Wössner
Eike Budde

Stuttgart, 25th of April 2023

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The report has:
139 pages of text
103 figures

Authors:
Simon Wössner
Eike Budde

Stuttgart, 18th of May 2023

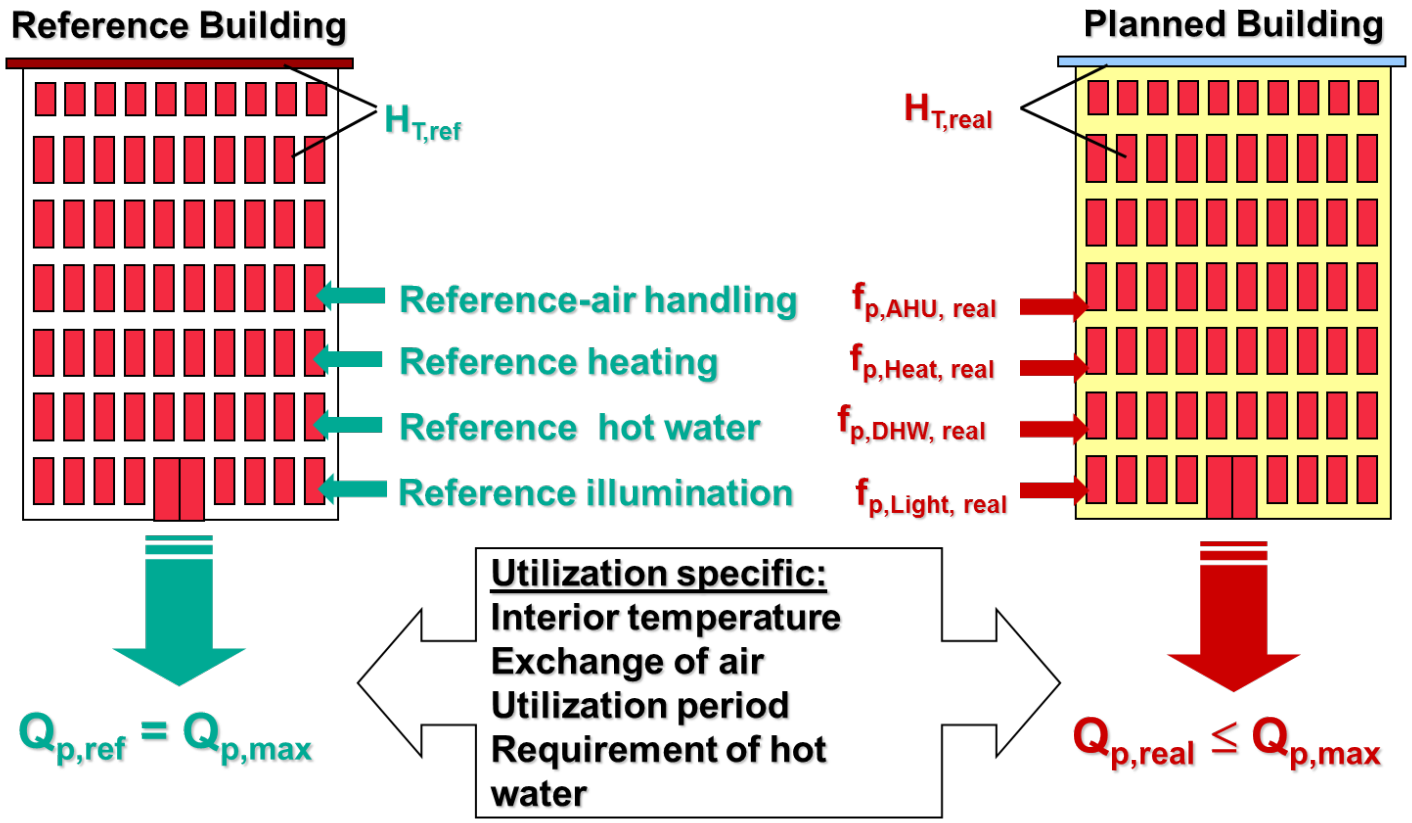
Recommendations

#	Parameters	Reference value		
		Climate Zone I	Climate Zone II	Climate Zone III
Heat transfer coefficient				
1	U-Value: External walls, walls to the garage, walls to the attic	0,40 W/m²K	0,30 W/m²K	0,3 W/m²K
2	U-Value: Windows, balcony doors, roof windows, transparent façade elements	2,0 W/m²K	2,0 W/m²K	1,3 W/m²K
3	U-Value: Flat and pitched roofs above heat space, ceilings towards the attic	0,40 W/m²K	0,40 W/m²K	0,30 W/m²K
4	U-Value: Ceilings beyond external air, ceilings beyond garages	0,40 W/m²K	0,40 W/m²K	0,30 W/m²K
5	U-Value: Walls and ceilings towards the non-heated rooms, non-heated stairs of temperature above 0 °C, rooms that are occasionally used and areas of other purpose	0,50 W/m²K	0,30 W/m²K	0,30 W/m²K
6	U-Value: Walls to the ground, floors on the ground	0,50 W/m²K	0,50 W/m²K	0,5 W/m²K
7	U-Value: Exterior doors, doors towards non-heated stairs, doors with opaque wing	2,9 W/m²K	2,9 W/m²K	2,9 W/m²K
Solar thermal properties				
8	g-Value window	0,60	0,60	0,60
9	Fc in wintertime	1,00	1,00	1,00
10	Fc in summertime	0,40	0,40	0,40
Other parameters for the building fabric				
11	Thermal bridges	In accordance with recommended solutions		
12	Condition of building	Windows and façade walls in normal condition		

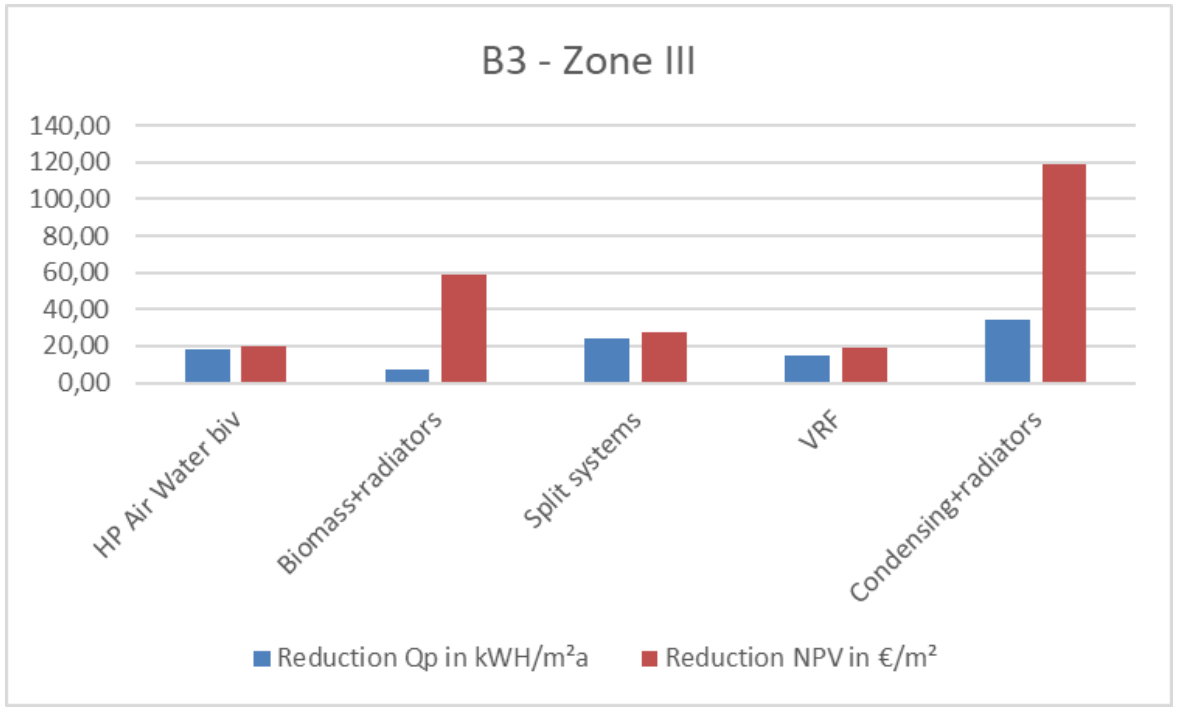
#	Parameters	Reference value
Heating - Central systems		
14	Generator	Heat pump air to water, single stage - bivalent with integrated el. Heater
15	Distribution	Distribution pipes outside, riser and connection pipes inside thermal hull.
16	Control and emission	Underfloor heating, wet, 40°C flow, 30°C return temperature
17	Storage	Indirect heated heat water storage
Heating - Decentral systems:		
18	Generator	Electrical VRF heat pump
Domestic hot water - Central systems		
19	Generator	Electrical air water heat pump in combination with heating,
20	Distribution	Distribution pipes outside, riser and connection pipes inside thermal hull.
21	Storage	Indirectly heated for Zone II+III, bivalent solar storage for Zone I
Domestic hot water - Decentral systems		
22	Generator, Distribution	Electrical flow heater with electronic control, only connection pipe inside thermal hull
Solar water heater		
23	Minimum contribution from solar hot water generation to overall hot water demand	Climate zone 1: 15% of net energy demand for domestic hot water Climate zone 2 and 3: no minimum requirement
24	Generator	Evacuated tube collector, storage
Cooling system		
25	Generator	Combined with heating
26	Distribution	For central systems: cold water pumps simplified calculation case 2
27	Control and emission	For central systems: 6/12°C flow/return, no fans For decentral: No fans, direct evaporation

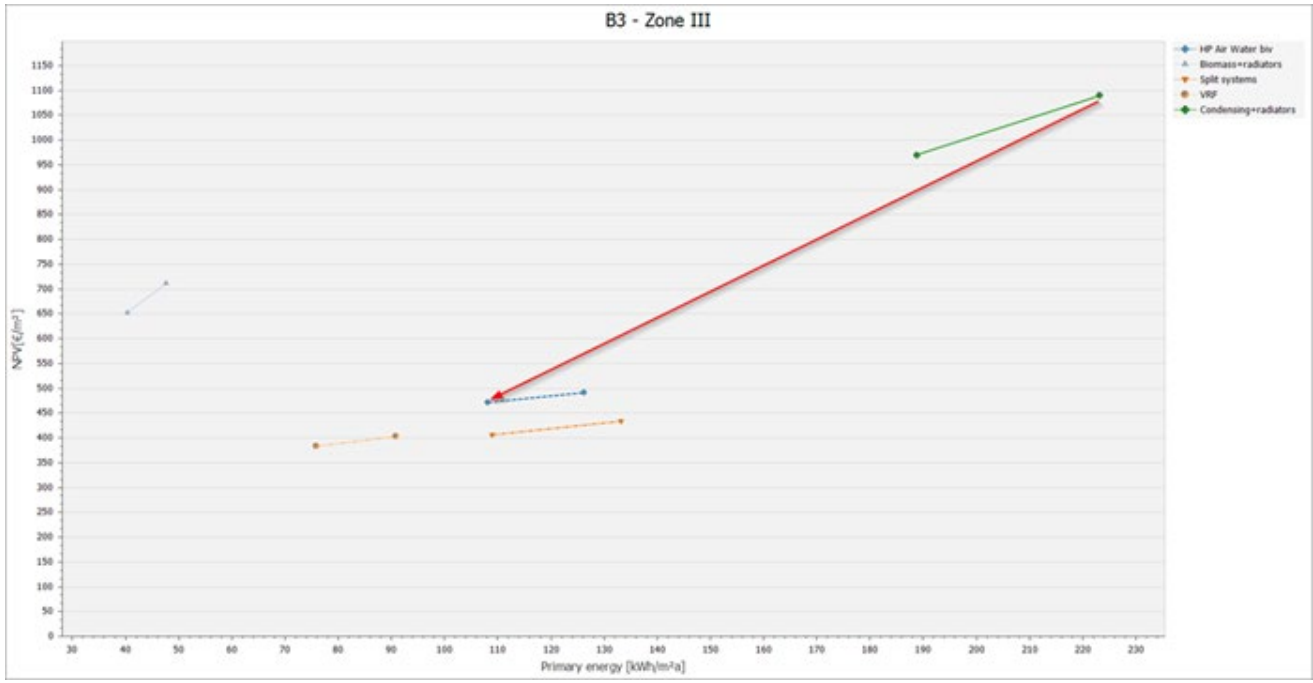
How to determine the overall energy performance?

Comparison with notional building approach:



Reduction by MEPR





Recommendation for the definition of classes and requirements

Table 3 — Example of classes of default energy rating method with a single reference point

Class	Example of classes for $n_{ref} = 4$
	EP < 0
Class 1	0 Ref < EP ≤ 0,35 Ref
Class 2	0,35 Ref < EP ≤ 0,50 Ref
Class 3	0,50 Ref < EP ≤ 0,71 Ref
Class 4	0,71 Ref < EP ≤ **1,00** Ref
Class 5	1,00 Ref < EP ≤ 1,41 Ref
Class 6	1,41 Ref < EP ≤ 2,00 Ref
Class 7	2,00 Ref < EP

Figure 1:
Default classes for the single reference point rating method.

Correction factor	New buildings		Existing buildings
	Residential buildings	Non-residential buildings	Major refurbishments
2013	1,0	1,0	1,4
2016	0,75	1,0	1,4
2023	0,55	0,55	1,4

Figure 2:
Correction factors for the calculation of the energy performance EP in Germany

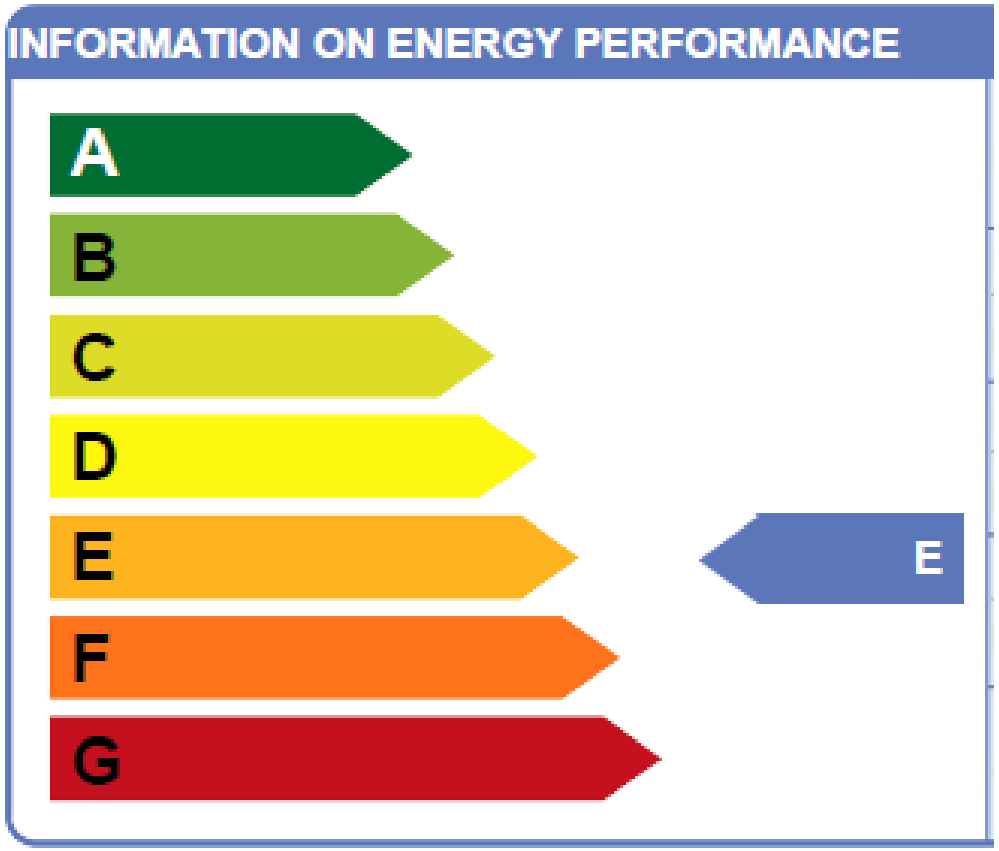
The Energy Performance (EP) to determine the class is calculated as follows:

$$EP = \frac{Primary\ energy\ demand\ assessed\ building}{Correction\ factor * primary\ energy\ demand\ notional\ building}$$

Formula 1:
Calculation of the energy performance of a building

Recommendations

- Results are not transferable
  - main input factors for differences are climate, costs and especially energy costs, conversion factors and especially the ratio of energy costs and conversion factors
- Getting „good“ costs takes time but is crucial for reliable results as cost optimal study is centerpiece behind rulebooks and laws



Outlook

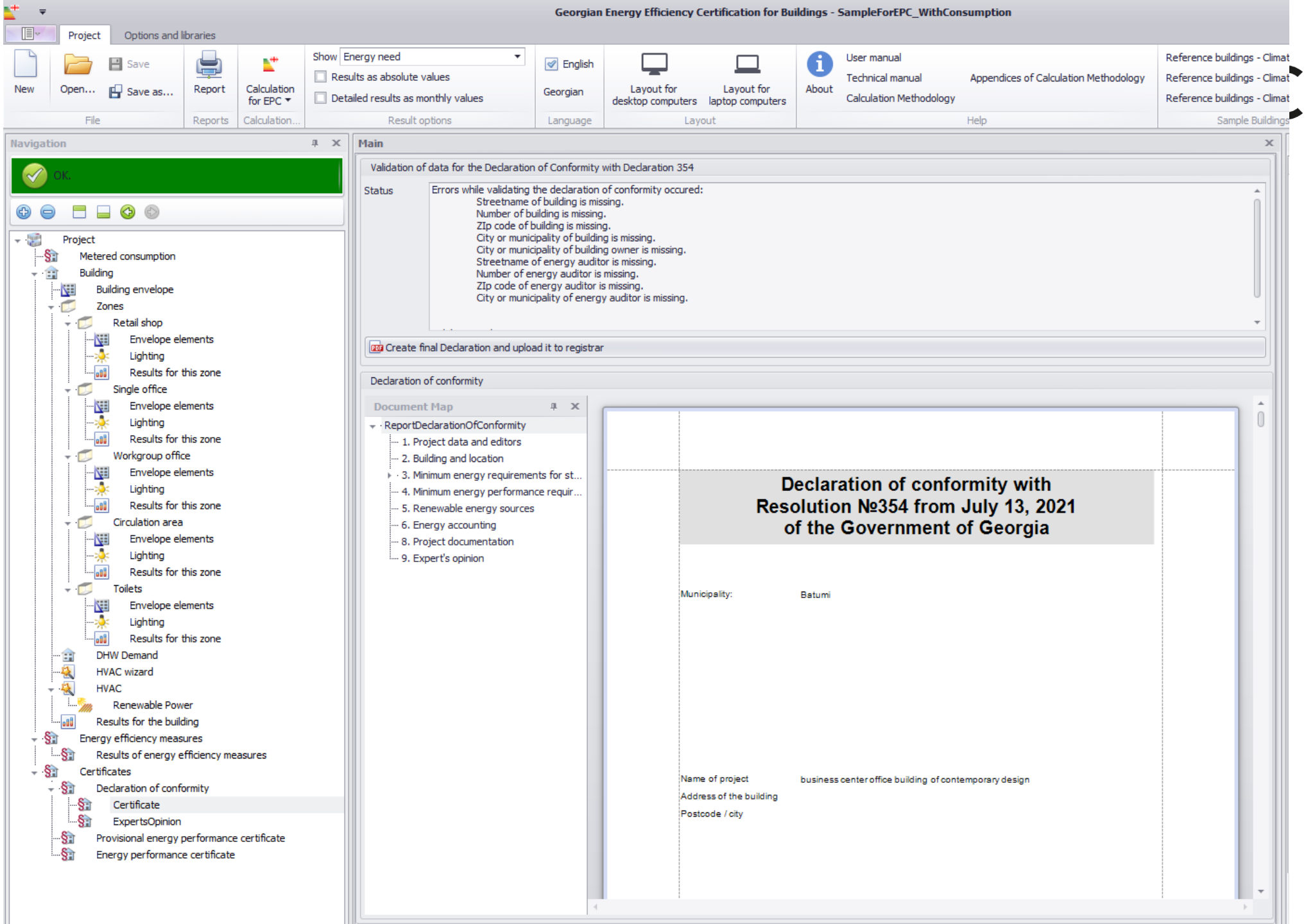
- Fully digitalized approach of EE in built envirnment supported in Georgia

GEECB Software
(By Fraunhofer IBP)

XLS Template for Energy audits in Industry
(By GESRP project)

Database (By Fraunhofer IBP)

XLS Template for H&C Inspection reporting
(By GESRP project)


Georgian Energy Efficiency Certification for Buildings - SampleForEPC_WithConsumption
Project
Options and libraries
New
Open...
Save
Save as...
Report
Calculation for EPC
Show
Energy need
Results as absolute values
Detailed results as monthly values
English
Georgian
Layout for desktop computers
Layout for laptop computers
About
User manual
Technical manual
Calculation Methodology
Appendices of Calculation Methodology
Reference buildings - Climat
Reference buildings - Climat
Reference buildings - Climat
File
Reports
Calculation...
Result options
Language
Layout
Help
Sample Buildings
Navigation
OK.
Project
Metered consumption
Building
Building envelope
Zones
Retail shop
Envelope elements
Lighting
Results for this zone
Single office
Envelope elements
Lighting
Results for this zone
Workgroup office
Envelope elements
Lighting
Results for this zone
Circulation area
Envelope elements
Lighting
Results for this zone
Toilets
Envelope elements
Lighting
Results for this zone
DHW Demand
HVAC wizard
HVAC
Renewable Power
Results for the building
Energy efficiency measures
Results of energy efficiency measures
Certificates
Declaration of conformity
Certificate
ExpertsOpinion
Provisional energy performance certificate
Energy performance certificate
Main
Validation of data for the Declaration of Conformity with Declaration 354
Status
Errors while validating the declaration of conformity occured:
Streetname of building is missing.
Number of building is missing.
ZIp code of building is missing.
City or municipality of building is missing.
City or municipality of building owner is missing.
Streetname of energy auditor is missing.
Number of energy auditor is missing.
ZIp code of energy auditor is missing.
City or municipality of energy auditor is missing.
Create final Declaration and upload it to registrar
Declaration of conformity
Document Map
ReportDeclarationOfConformity
1. Project data and editors
2. Building and location
3. Minimum energy requirements for st...
4. Minimum energy performance requir...
5. Renewable energy sources
6. Energy accounting
8. Project documentation
9. Expert's opinion
Declaration of conformity with
Resolution №354 from July 13, 2021
of the Government of Georgia
Municipality:
Batumi
Name of project
business center office building of contemporary design
Address of the building
Postcode / city

eXpressApp Framework

Registry Item For Declaration Of Conformity

Filter...

Default

- Adress Info For Registry
- Users
- Contact
- EPCAuditor
- My Details
- Role
- Registry Item For Declaration Of Conformity

New | Delete | Refresh | Text to search...

Registry Number	Municip...	IDAddress Of Building	Address Of Building	IDAddress Of Building Owner	Address Of Building Owner	Date Submitted	State Of Approval	str Xml Results While Submit...	Xml Results While Submitti...	Date Submitted Experts Opinion	State Of Approval Experts Opinion	IDAddress Of Expert	Adc Of E
						1/1/0001				1/1/0001			
						1/1/0001				1/1/0001			
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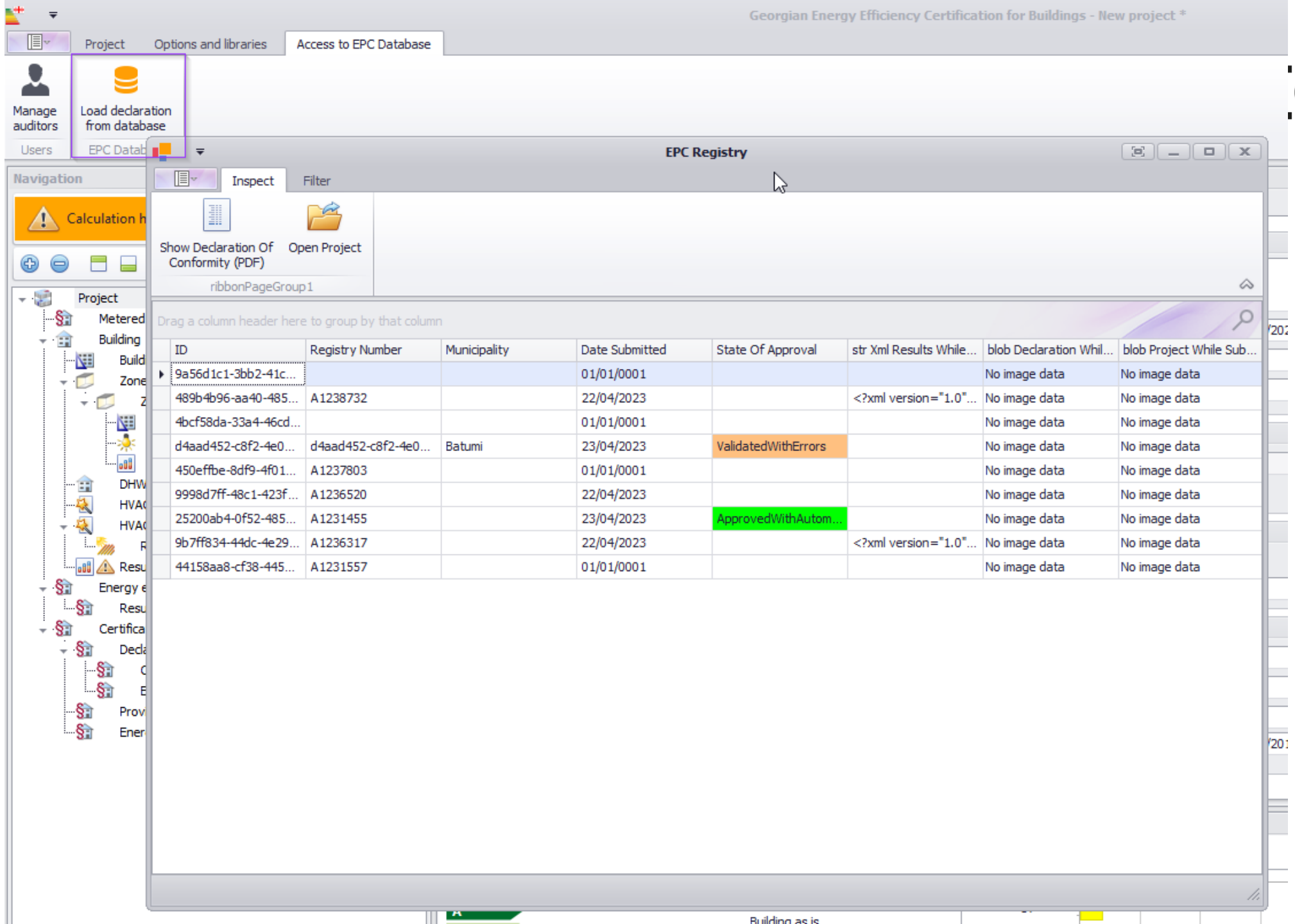
Georgian Energy Efficiency Certification for Buildings - New project *
Project
Options and libraries
Access to EPC Database
Manage auditors
Users
Load declaration from database
EPC Datab
EPC Registry
Inspect
Filter
Show Declaration Of Conformity (PDF)
Open Project
ribbonPageGroup1
Navigation
Calculation h
Project
Metered
Building
Drag a column header here to group by that column
ID
Registry Number
Municipality
Date Submitted
State Of Approval
str Xml Results While...
blob Declaration Whil...
blob Project While Sub...
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01/01/0001
No image data
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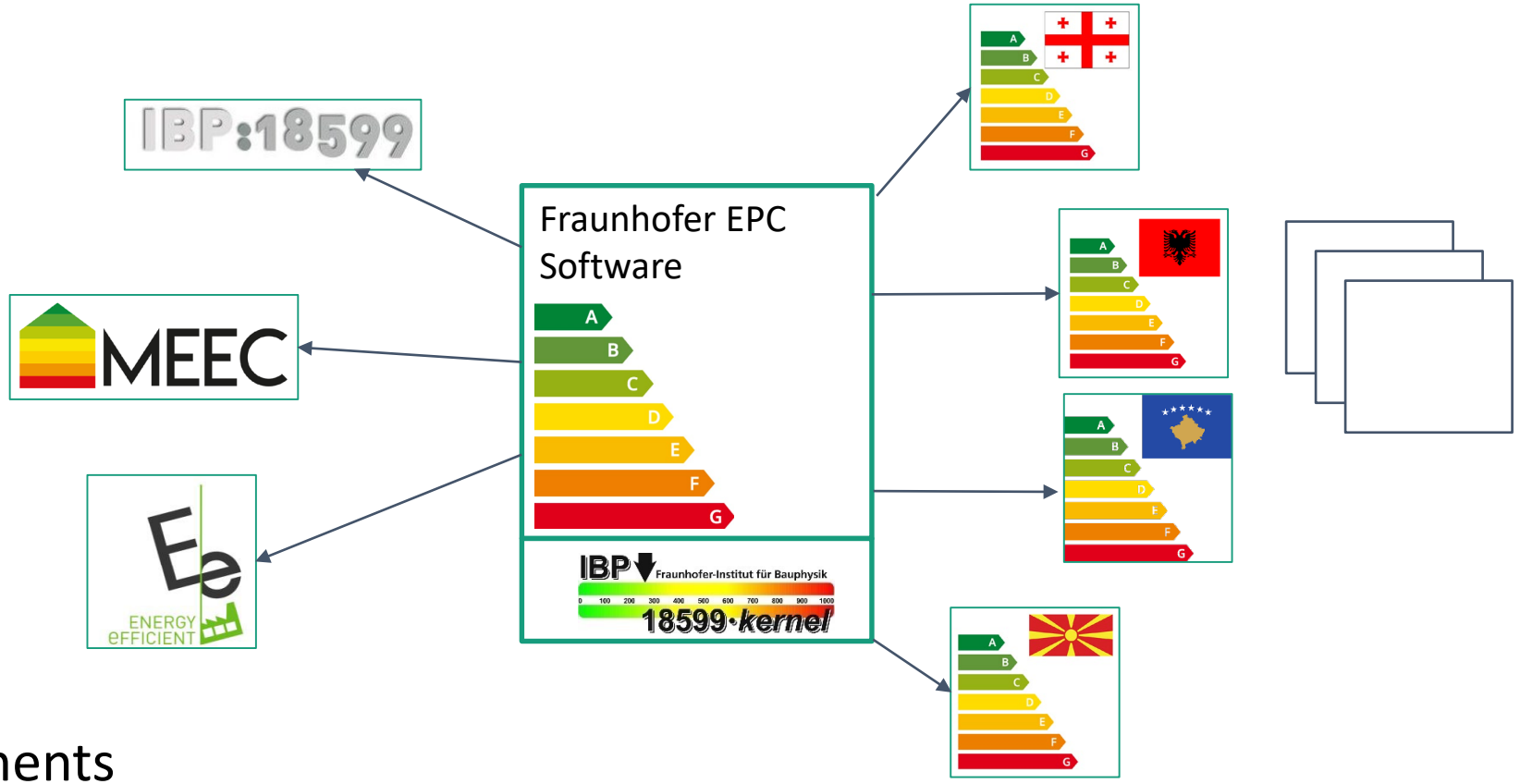
Thank you!



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