BUILDING ENERGY EFFICIENCY

-

the Bulgarian experience

Prof. Dr. Nikola Kaloyanov, Board of Directors BGBC, “Bulgaria’s Green Energy Challenges “ , October 10th 2012

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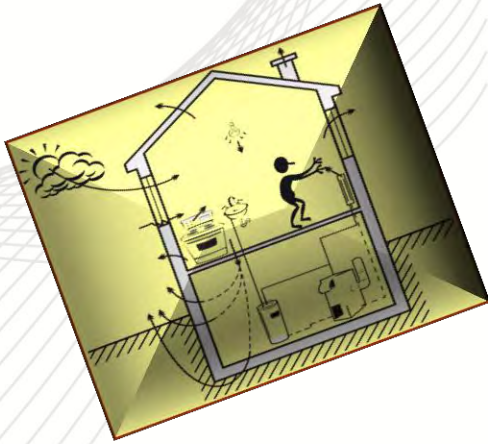
Energy Performance of Buildings Directive - five main requirements

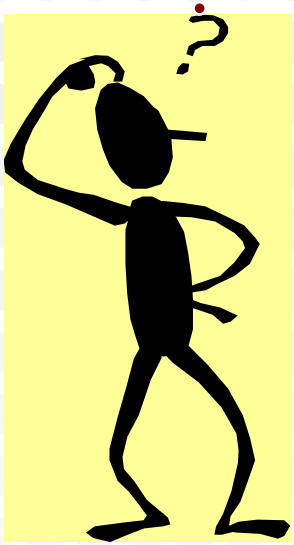
- Development of methodology for integrated energy performance standards (**Calculation procedure**).
- Development of standards for new and renovated buildings.
- Development of certification schemes for new and existing buildings.
- Development of procedures for inspection of boilers and AC systems.
- Training of independent inspectors (quality assurance).

THE EU DIRECTIVE REQUIREMENTS

- ✓Transmission
- ✓Ventilation
- ✓Internal gains
- ✓Solar gains
- ✓Heating
- ✓Cooling
- ✓Lighting
- ✓RE thermal; RE electric



...energy efficiency in buildings???



1. What is the framework…
2. What are the good EU practices…
3. Where is Bulgaria in this field…

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More than 50 CEN standards for implementation of the EPBD

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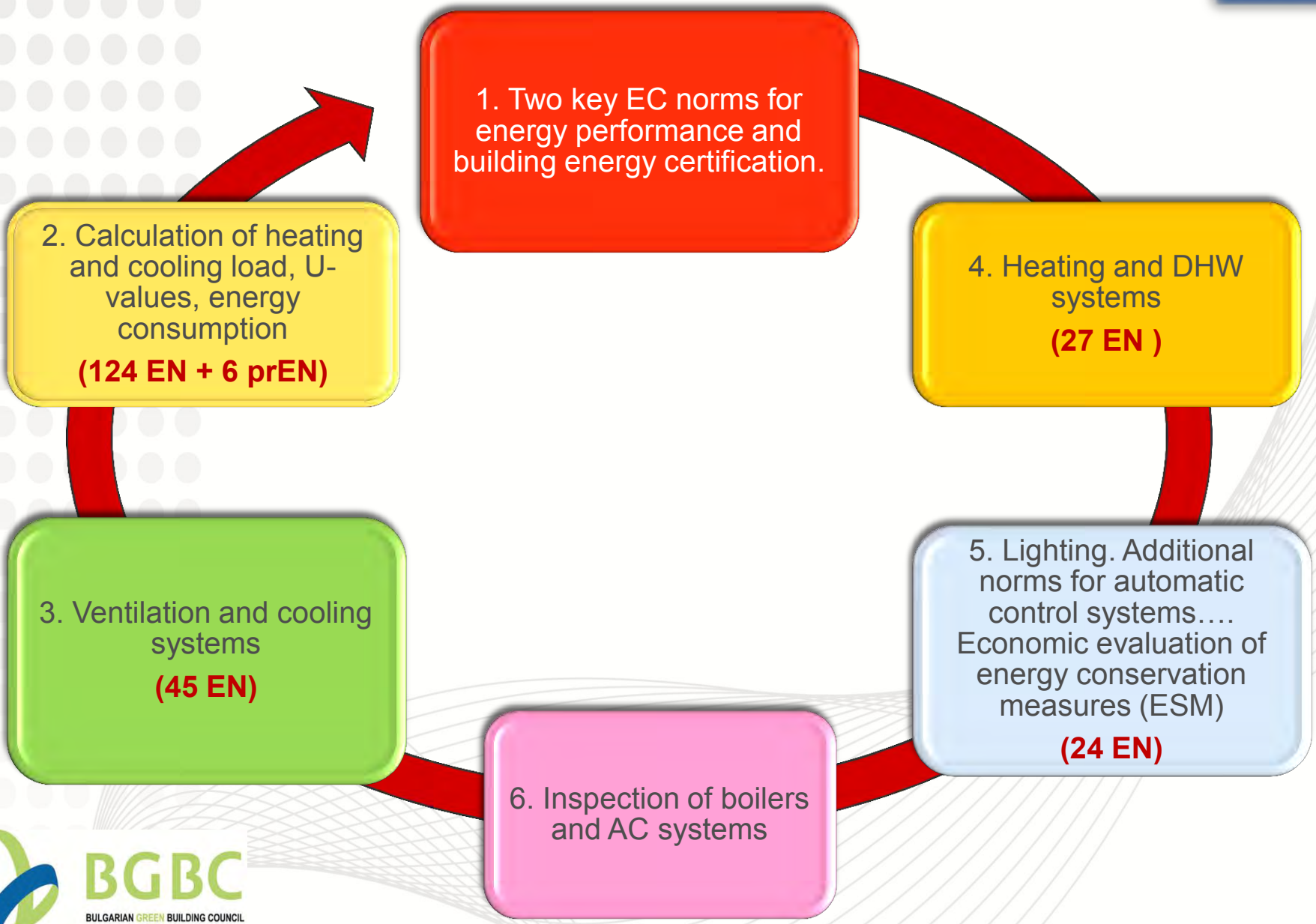

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The concept

“End energy”,
“Primary energy”
“CO_2 equivalent”

$$Q = \sum_{i=1}^{m} Q_{i,н} \cdot e_i$$

$$CO_2 = \left(\sum_{i=1}^{m} Q_{i,п} \cdot f_i \right) .10^{-6}, \text{tones}$$

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What is done in Bulgaria

Legal context

- New Energy Law – December 2003
- New Energy Efficiency Law – March 2004
- Updated Law for Spatial Planning – 2004, 2006
- New Law for RES utilisation - 2007
- New Energy Efficiency Law – August 2008 (2006/32)

Main ordinances

- Designing of HVAC systems
- Industrial Energy Auditing
- Heat retention in buildings
- ……..
- Building Energy Performance
- Building auditing and energy certification
- Registering of auditors
- Inspection of boilers and AC

Building energy certification started in Bulgaria January 1, 2005

Responsibility for implementation of the EPBD in Bulgaria

- Ministry of Economy , Energy and Tourism
- Ministry of Regional Development and Public Works
- Agency for Sustainable Energy Development (SEDA)

Scientific support has been done by the Technical University of Sofia

- **Team of the TUS has developed:**

- indicators for evaluation of building energy performance,

- methodology for building energy auditing,

- procedures and software for:

  building modeling and simulation, evaluation of annual energy consumption and building energy certification,

- national system for training of energy auditors,

- prototypes of National Energy Certificate and National Energy Passport.

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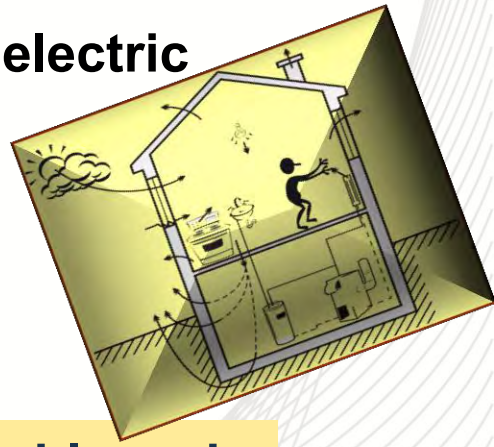
THE BULGARIAN METHODOLOGY

THE EU DIRECTIVE REQUIREMENTS

- ✓Transmission
- ✓Ventilation
- ✓Internal gains
- ✓Solar gains
- ✓Heating
- ✓Cooling
- ✓Lighting
- ✓RE thermal; RE electric



THE BULGARIAN METHODOLOGY INCLUDES

- ✓Heat transmission through building envelope
- ✓Ventilation
- ✓Heating and DHW systems
- ✓Cooling

- ✓Internal (exploitable and unexploitable) gains
- ✓Lighting
- ✓Solar gains
- ✓Night ventilation
- ✓RES utilisation

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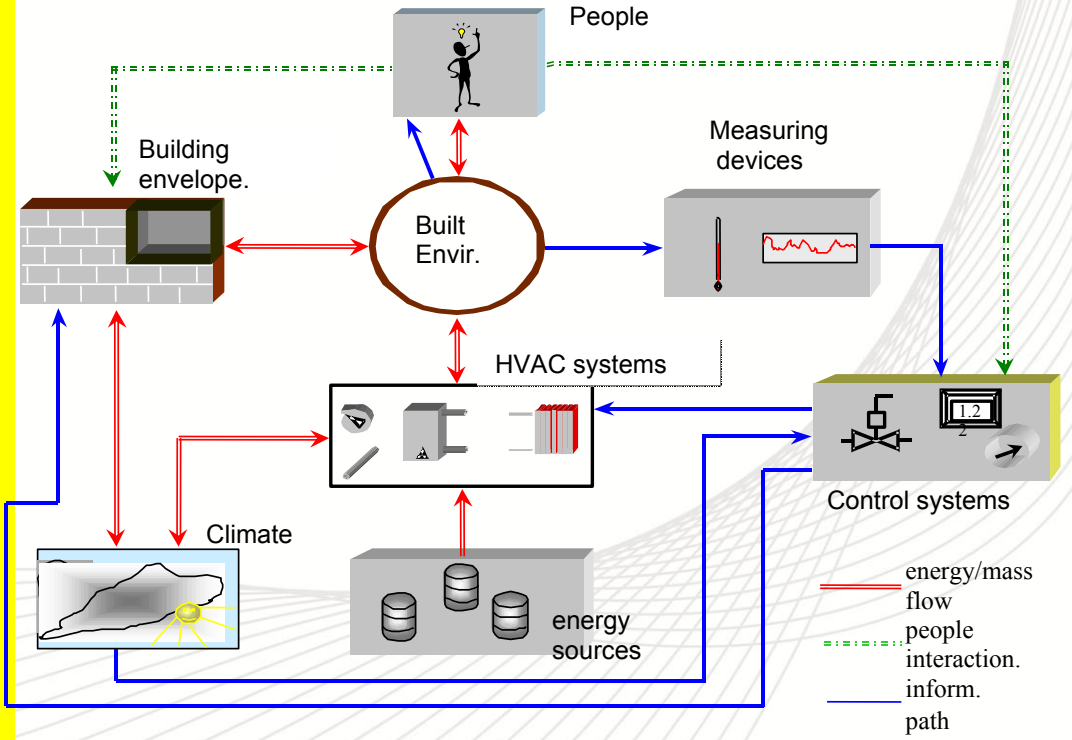
National methodology

Energy performance indicators of the building specified at three levels:

- **Level 1.** For the components of the building envelope and HVAC systems and lighting
- **Level 2.** For the main energy consuming technology processes in the building (heating-ventilation , cooling, domestic hot water preparation and lighting)
- **Level 3.** For the building as an integrated system (total energy consumption)



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Level 1

- **For the components of the building envelope and HVAC systems and lighting**

- The overall heat transfer coefficient through the external walls , W/m^2K ;
- The overall heat transfer coefficient through the windows , W/m^2K ;
- The overall heat transfer coefficient through the roof , W/m^2K ;
- The overall heat transfer coefficient through the floor (to the external air) , W/m^2K ;
- The efficiency of heat /cold generation unit (boiler efficiency) , %
- The efficiency of heat distribution systems to the conditioned space , %
- ……

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Level 2

❖ **For the main energy consuming technology processes in the building (heating-ventilation , cooling, domestic hot water preparation and lighting)**

- Total infiltration heat losses, kW;
- Specific heat transfer losses through the building envelope, W/m^3
- Specific infiltration losses , W/m^3
- Total heat losses , kW
- Total specific heat losses , W/m^3
- Annual energy consumption for heating/cooling , kWh
- Specific annual energy consumption for heating per heated area, kWh/m^2DD
- Specific annual energy consumption for heating per heated volume , kWh/m^3DD
- Annual energy consumption for domestic hot water (DHW) , kWh
- Specific annual energy consumption for DHW per conditioned area, kWh/m^2
- Annual energy consumption for lighting , kWh
- Specific annual energy consumption for lighting per conditioned area, kWh/m^2
- ……..

Level 3

❖**For the building as an integrated system (total energy consumption, CO_2 equivalent)**

- Total “thermal power” for heating, ventilation and DHW, kW
- Total specific “thermal” for heating, ventilation and DHW, kW/m^2
- Total “electrical” power for heating, ventilation and DHW, kW
- Total specific “electrical” power for heating, cooling, ventilation and DHW, kW/m^2
- Annual energy consumption for heating, cooling, ventilation and DHW, kWh/year
- Specific annual energy consumption for heating, cooling,ventilation and DHW, kWh/m^2
- **Specific annual energy consumption for heating, ventilation and DHW, Wh/m^3.DD.**

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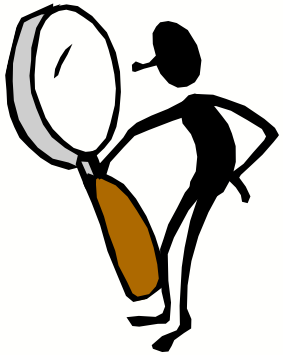
National methodology

Existing building or new design

+



Inspection and energy analysis by registered experts

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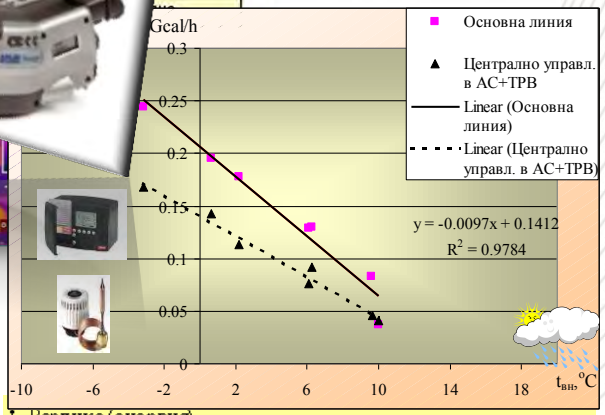
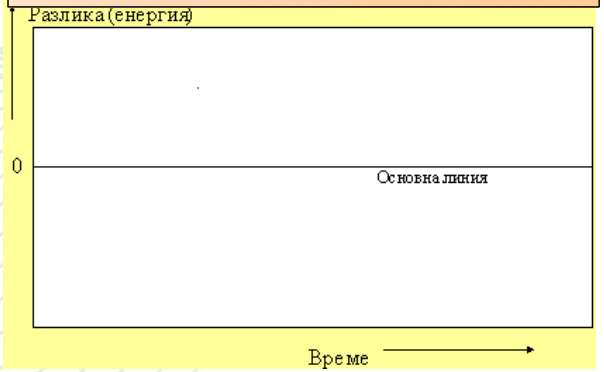
National methodology

- Systematic approach for building energy auditing
- Specific measurements and procedure for collecting initial data
- Procedure for data treatment
- Building energy modeling and simulation



Отопление

	1 Параметър	2 Еталон	3 Състояние	4 Базова линия	5 Чувствителност	6 Енергоспест. мерки	7 След ECM
Отопление		57,6	kWh/m²y				
U - стени	1,00	W/m²K	1,26	1,26	+ 0,1 W/m²K = 3,88	1,00	-8,36
U - прозорци	2,65	W/m²K	2,92	2,92	+ 0,1 W/m²K = 1,66	2,65	-3,73
U - покрив	0,60	W/m²K	1,00	1,00	+ 0,1 W/m²K = 2,08	0,60	-6,90
U - под	0,30	W/m²K	0,46	0,46	+ 0,1 W/m²K = 2,08	0,46	
Фактор на формата	0,42	-	0,34	0,34		0,34	
Площ прозорци	24,0	%	23,9	23,9		23,9	
Коеф. на енергопрем.	0,56	-	0,55	0,55	+ 0,1 = 0,00	0,58	
Инфилтрация	0,50	1/h	0,83	0,83	+ 0,1 1/ h = 12,35	0,50	-33,60
Проектна темп.	18,5	°C	16,8	16,5	+ 1 °C = 12,93	18,5	
Темп. с понижение	13,5	°C	12,0	13,5	+ 1 °C = 6,57	13,5	
Приноси от :							
От вентилация		kWh/m²y	6,78	10,50		10,50	
Осветление		kWh/m²y	2,01	2,07		2,03	
Други		kWh/m²y	6,02	6,22		4,05	
Сума 1		**kWh/m²y**	**72,4**	**86,3**		**47,3**	
Загуби разпр. мрежа	3,0	%	10,0	10,0		4,0	-8,87
Автомат. управление	97,0	%	Ръчно	Ръчно	Лошо = -3 %, Ръчно = -5 %	Автомат.	-5,67
Сума 2		**kWh/m²y**	**87,4**	**104,2**		**59,8**	
Е & П / ЕМ	96,0	%	96,0	96,0		96,0	
Сума 3		**kWh/m²y**	**91,1**	**108,5**		**53,0**	
КПД на топлоснабд.	100,0	%	82,0	82,0		87,0	-6,33
Отопление коригирано		**kWh/m²y**	**111,0**	**132,3**		**60,9**	



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THE APPROACH
for assessment of the annual energy consumption:

Measurements + Calculations

The algorithm – developed in 1994

Building zoning — 1

- Building envelope
- Zone function
- Operating regime
- Heating/cooling of the zone

Measured heat, electricity and water consumption

existing buildings only

Building's energy model — 2

Test reference year (climate data)

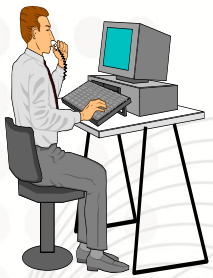
3 Model calibration

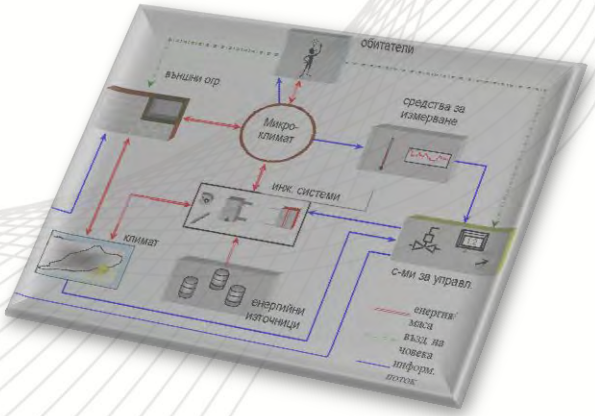
4 Model "normalisation"

5 EP and EP_{max}

6 Simulation of ECM

7 Economic evaluation of ECM





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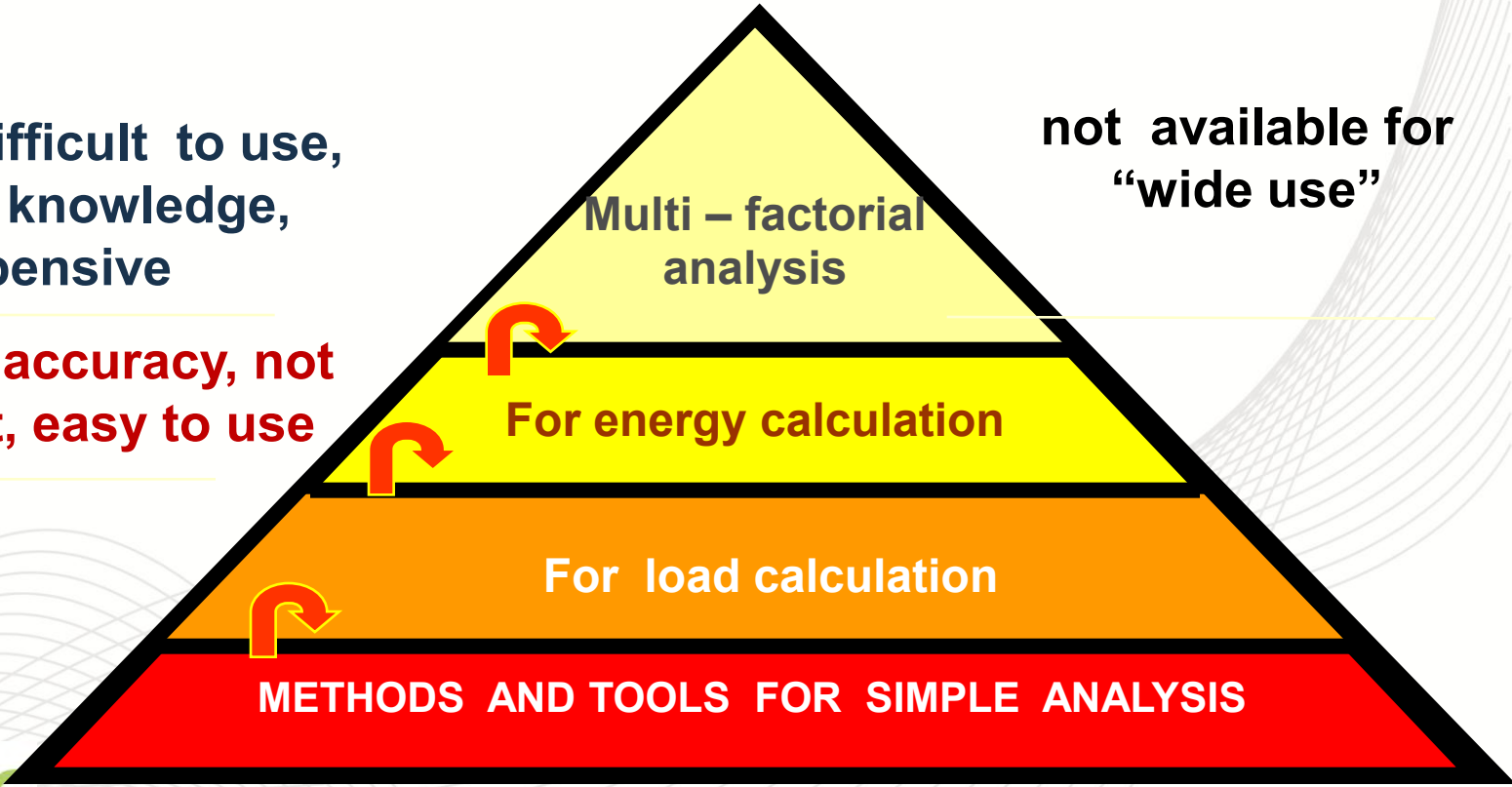
Which method for calculation of annual energy consumption is more appropriate ?

Functional analysis of the methods

precise, difficult to use, special knowledge, expensive

Reasonable accuracy, not heavy input, easy to use



not available for "wide use"

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Our conclusion

Even there are very sophisticated and detailed methods, until now

- EN ISO 13790

seems to be the most “appropriate” method.

It provides more “practical” advantages, as:

- easy to understand and use;
- reasonable accuracy;
- can be computerized with simple algorithms.

We upgraded the method with hourly models for humidity balance (cooling mode) and developed software package for building energy modelling and simulation.

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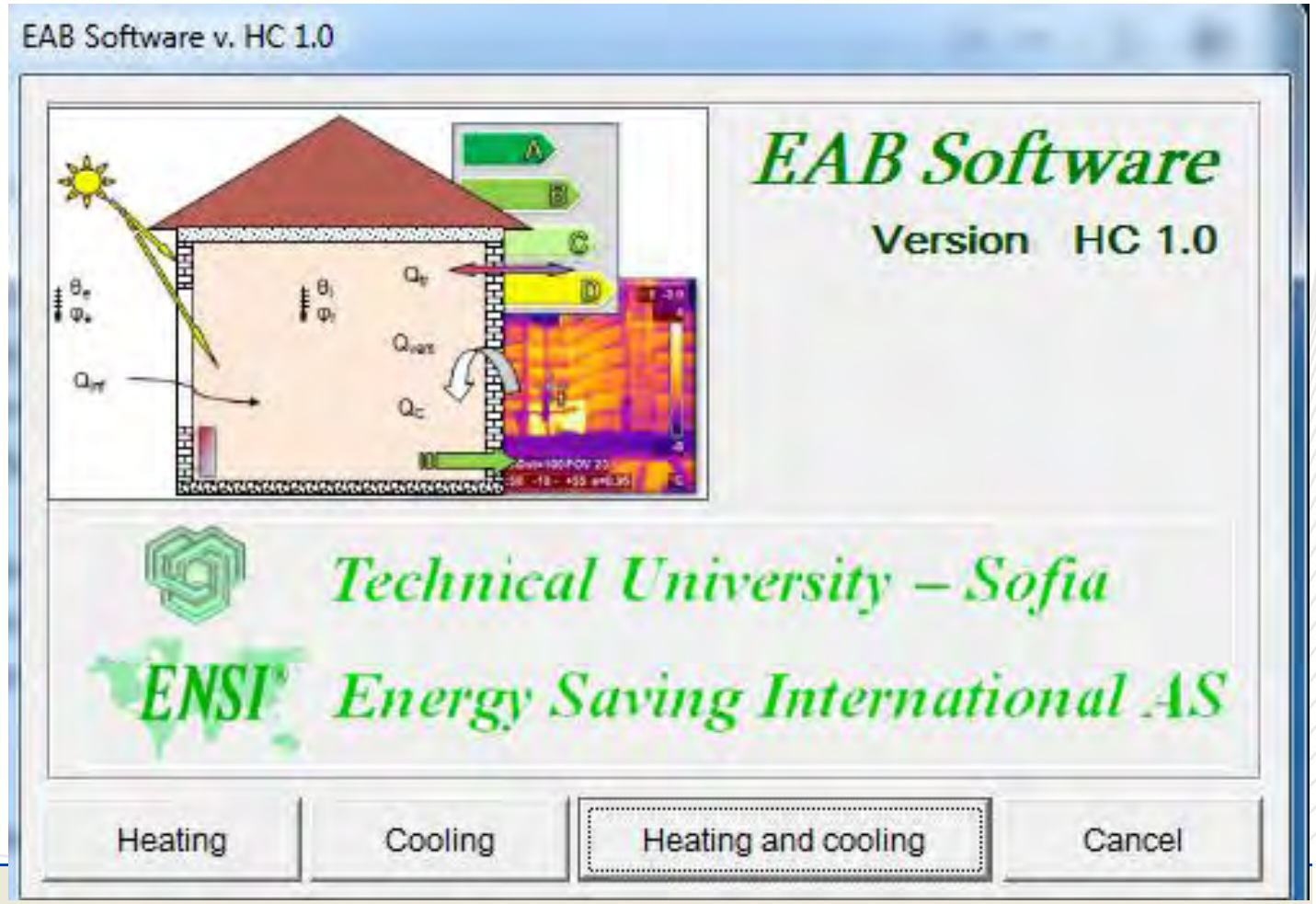

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The energy consumption scale

Boundaries	Energy consump-tion label	Description
$EP \leq 0{,}5\ EP_{max,r}$	A	Low energy consumption
$0{,}5\ EP_{max,r} < EP \leq EP_{max,r}$	B	
$EP_{max,r} < EP \leq 0{,}5(EP_{max,r} + EP_{max,s})$	C	
$0{,}5\ (EP_{max,r} + EP_{max,s}) < EP \leq EP_{max,s}$	D	
$EP_{max,s} < EP \leq 1{,}25\ EP_{max,s}$	E	
$EP_{max,s} < EP \leq 1{,}5\ EP_{max,s}$	F	
$1{,}5\ EP_{max,s} < EP$	G	High energy consumption

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How to obtain value of "minimum annual energy consumption" for a group of buildings ?

1. By statistical analysis of historical data for energy consumption.

- - how to constitute the group of buildings?
- - what is the representative period for data?
- - real measured data for the energy consumption (and the real climate)???
- - is there recorded inside temperature?
- - what was the occupation schedule during the historical period?

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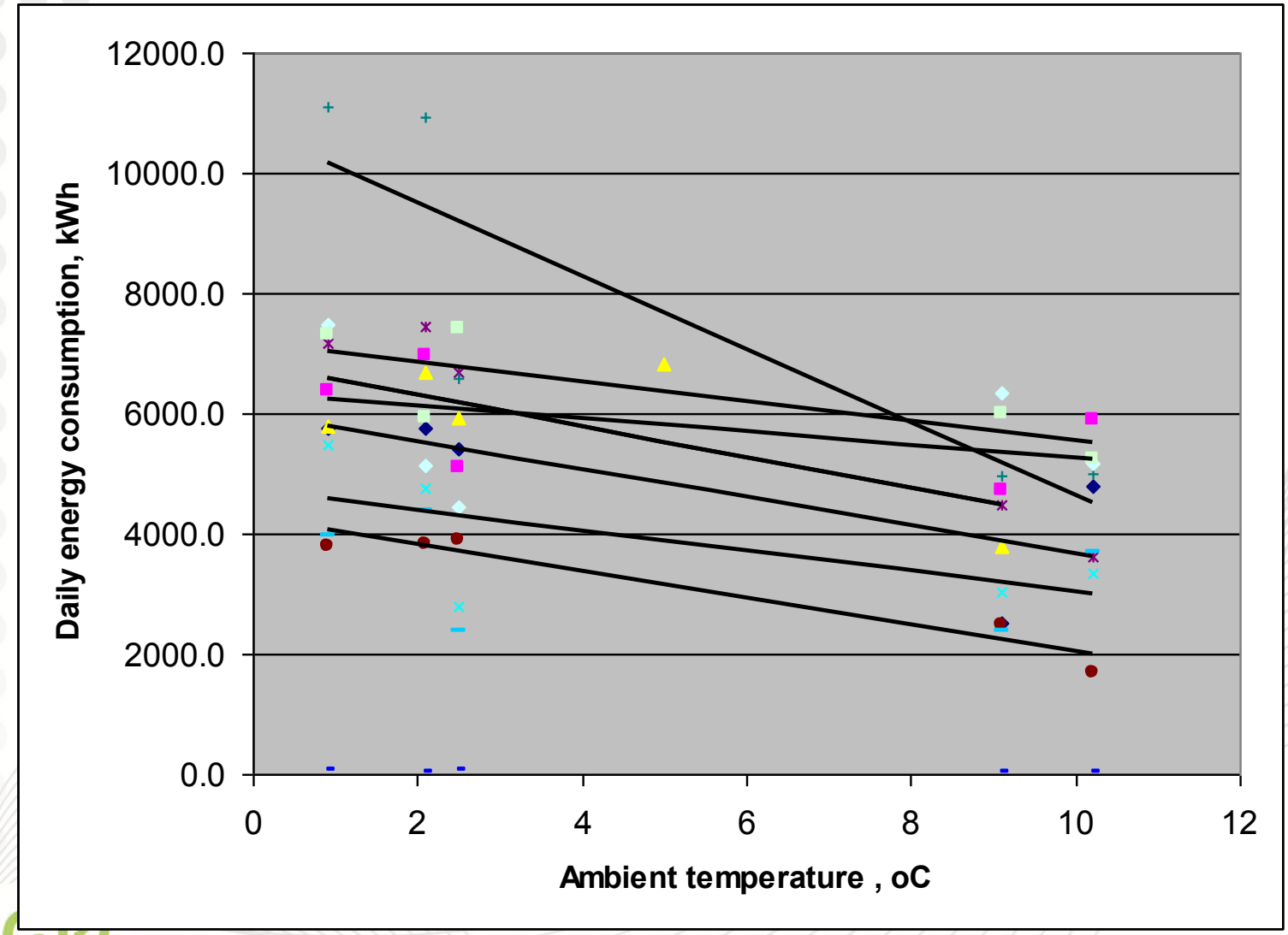
Example: Baseline energy consumption of 10 schools



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2. By modelling and simulation

- + how to select representative building/s for the specific group ?
- + how many buildings have to be modelled for one group?
- + accurate modelling and simulation require detailed audit
- +.....

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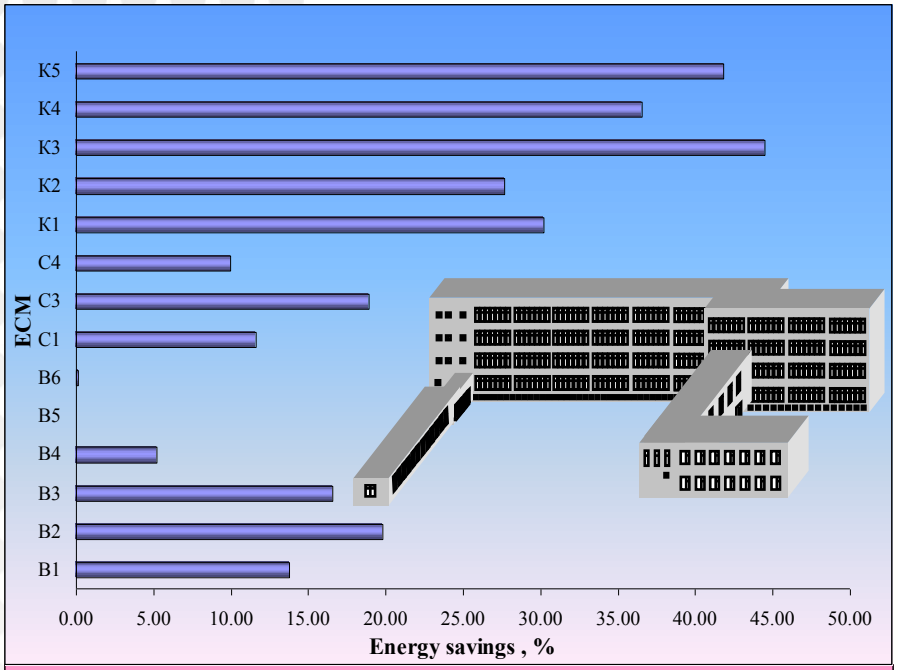
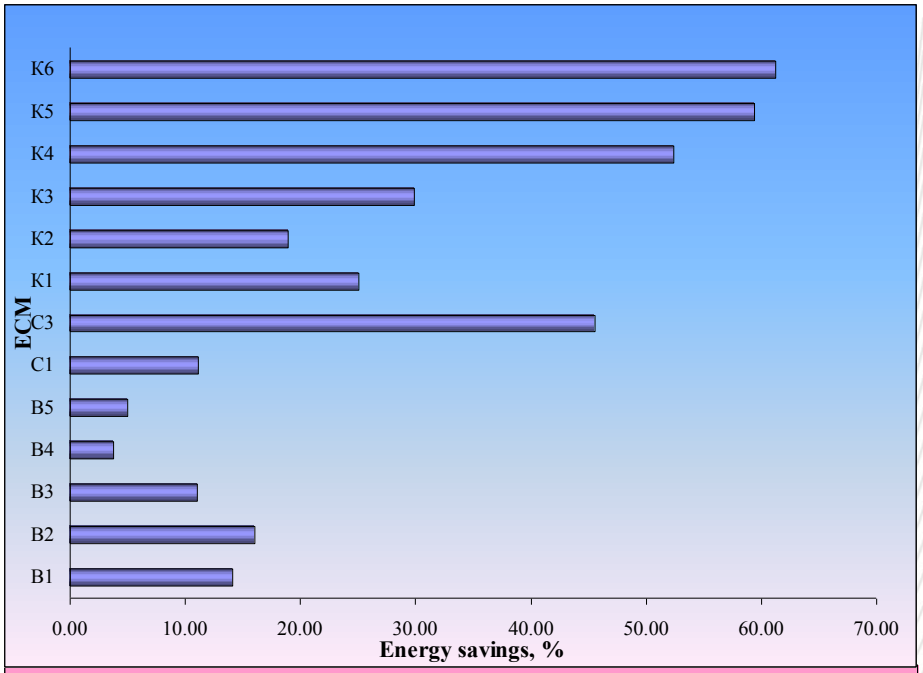
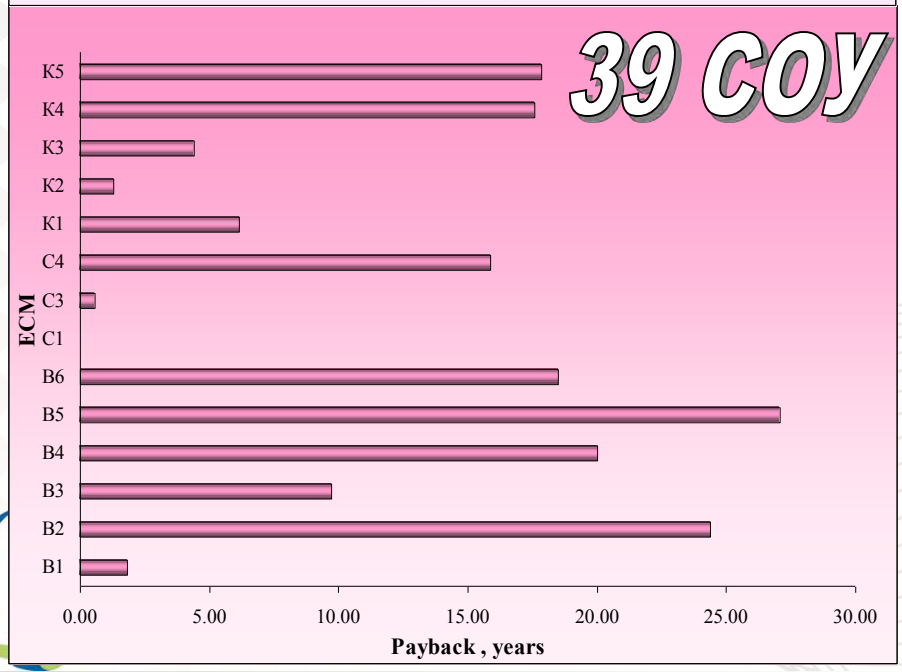
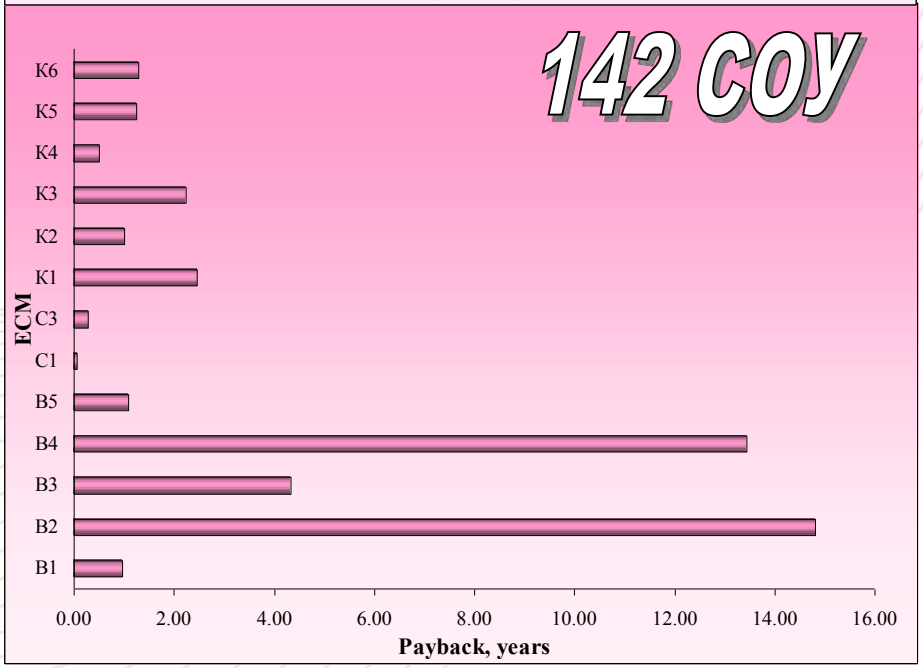

K5
K4
K3
K2
K1
C4
C3
C1
B6
B5
B4
B3
B2
B1
ECM
0.00 5.00 10.00 15.00 20.00 25.00 30.00 35.00 40.00 45.00 50.00
Energy savings , %


K6
K5
K4
K3
K2
K1
C3
C1
B5
B4
B3
B2
B1
ECM
0.00 10.00 20.00 30.00 40.00 50.00 60.00 70.00
Energy savings, %


39 COY
K5
K4
K3
K2
K1
C4
C3
C1
B6
B5
B4
B3
B2
B1
ECM
0.00 5.00 10.00 15.00 20.00 25.00 30.00
Payback , years


142 COY
K6
K5
K4
K3
K2
K1
C3
C1
B5
B4
B3
B2
B1
ECM
0.00 2.00 4.00 6.00 8.00 10.00 12.00 14.00 16.00
Payback, years

OUR CONCLUSION

- Value of “minimum energy consumption” can be representative only for a very small group.
- Each building has its own specifity and **reference energy consumption** = “***minimum energy consumption”.***
- The reference consumption can be found by means of calculation (EN ISO 13790), using the normative values of the building envelope, HVAC systems, … parameters (Level 1). The last are available in the national norms.

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Certification of buildings

1. Defined by the Ordinance for Energy efficiency certification of buildings - in force since 1 January 2005, updated 2009.
2. The SEDA is responsible for whole the process of certification, including National Register for the accredited companies.
3. The Energy building certification is carried out after obtaining the building permission for use only.
4. Certification is obligatory for public buildings /state or municipal property/ with gross useful floor area over 1000 m^2.
5. **Energy certificate for block of flats is issued for the whole building only, not for a separate apartment**.

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Certification of buildings

- **Certification and B&AC inspection is carried out by legal companies which:**

1. Are registered under the Trade law;
2. Are registered by the Energy Efficiency Agency;
3. Have the necessary technical means and measurement tools;
4. Employ necessary staff – persons with:
   a) higher technical education and not less than 3 years of experience or secondary-technical education and not less than 6 years of experience.
   b) successfully passed exam.

The auditors are registered by the SEDA.

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СЕРТИФИКАТ

за енергийните характеристики на сграда

Номер	Категория	Валиден до:

Сграда		
Адрес		
Въведена в експлоатация		
Застроена площ		m^2
Отопляема площ		m^2
Отопляем обем		m^3

Снимка на сградата

Скала на енергопотреблението	Състояние
A	
B	
C	
D	D
E	
F	
G	

ЕНЕРГИЙНИ ХАРАКТЕРИСТИКИ	
Специфичен разход на енергия	... kWh/m^2
Годишен разход на енергия	... MWh
Емисии CO_2	... т/год.

РАЗПРЕДЕЛЕНИЕ НА ГОДИШНИЯ РАЗХОД НА ЕНЕРГИЯ					ДЯЛ на ВЕИ
Отопление	Вентилация	Охлаждане	Горяща вода	Осветление	
... %	... %	... %	... %	... %	... %

Издаден на	Издаден от	Рег.номер

Срок на освобождаване от данък сгради
От: дд/мм/гг до: дд/мм/гг

Подпис, печат

ЕНЕРГИЕН ПАСПОРТ

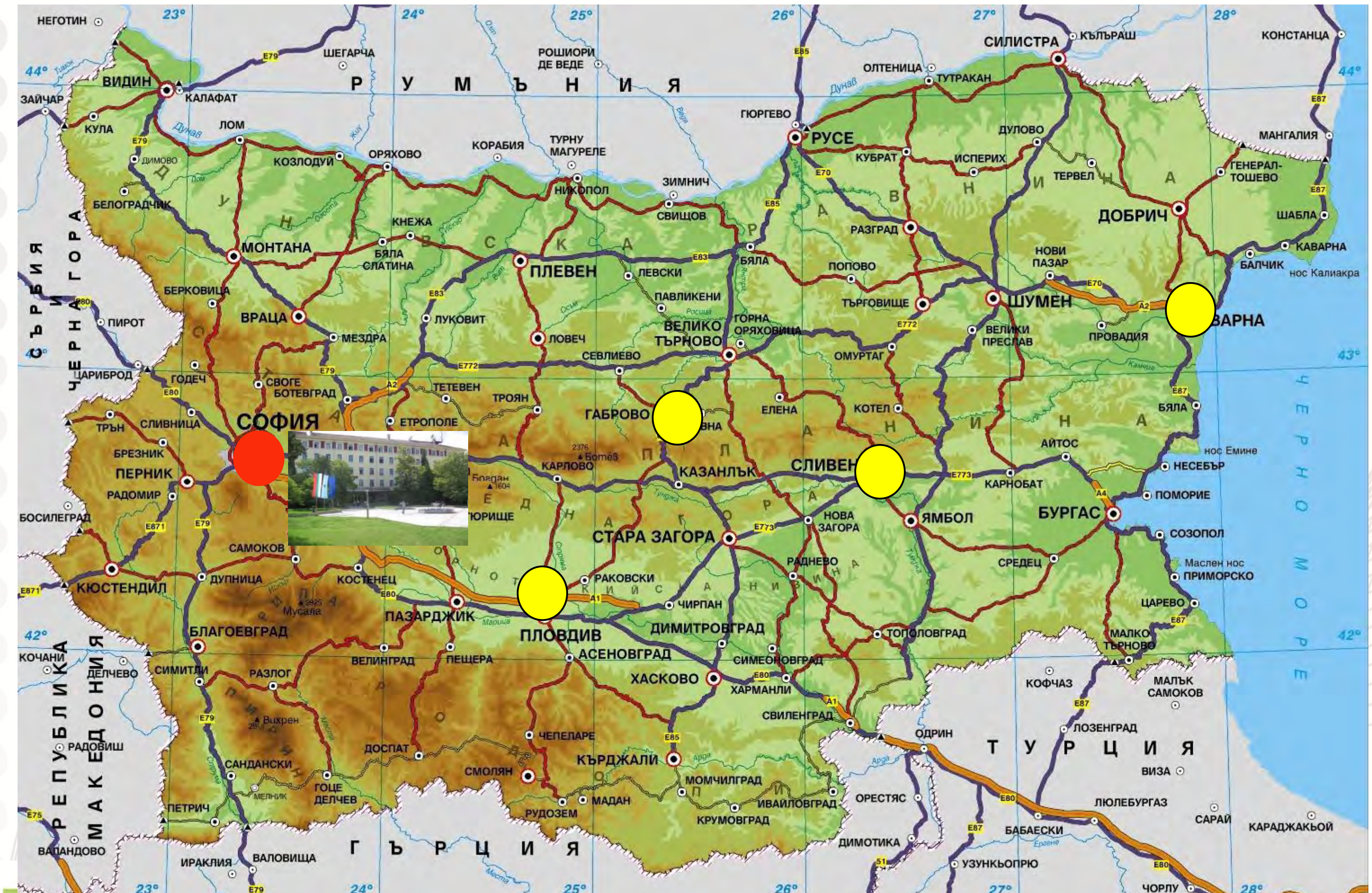
Сграда	Бизнес комплекс БЕЛЛИССИМО	
Адрес	София, бул. България 102	
Състояние	В експлоатация от 2006 год.	
Застроена площ	1743	m^2
Отопляема площ	12497	m^2
Отопляем обем	42363	m^3

Скала на енергопотреблението	Актуално състояние	След ЕСМ
A		
B	B	B
C		
D		
E		
F		
G		

ЕНЕРГИЙНИ ХАРАКТЕРИС-ТИКИ	Потребна енергия				Първична енергия	
	По норми при влизане в експлоа-тация	По действа-щите към момента норми	Актуално състояние	След ЕСМ	Актуално състояние	След ЕСМ
Специфичен разход на енергия	205,6 kWh/m^2	205,6 kWh/m^2	171,6 kWh/m^2	167,9 kWh/m^2	342,46 kWh/m^2	338,4 kWh/m^2
Годишен разход на енергия	2569399,6 MWh	2569399,6 MWh	2144001 MWh	2098583 MWh	4279406 MWh	4229446 MWh
Емисии CO_2					2380 т/год.	2367 т/год.

Съставен на	Съставен от
28.04.2008 г.	ТУ-София-Технологии ЕООД

Training of experts in a network of 4 Universities



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The training

- Since May 2005 : **3 Weeks (90 hours) training course for building auditors**

- **Part A: Theoretical**

46 hours lectures

- **Part B: Practical work**
- 14 hours seminars

+

- 30 hours Individual Team Project for building energy analysis and certification

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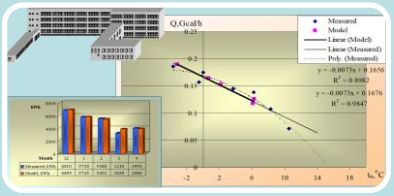
Content of the individual test

National legislation concerning building energy certification (10 %)

- The Energy Efficiency Law and the Ordinances for building energy certification
- The Law for Spatial Planning and the Ordinance for energy conservation in buildings

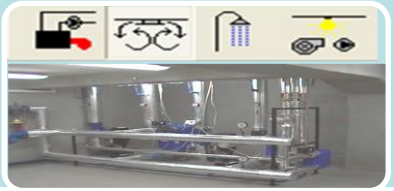
Building physics fundamentals (10 %)

- Building envelope
- Thermal, optical and electrical parameters. Units and conversion
- Measuring of thermal and electrical parameters



National methodology for building energy performance evaluation (60%)

- Energy auditing, assessment of annual energy consumption, ECM, building certification
- Economic evaluation of ECM, building energy certification



Building systems (20%)

Boilers and burning systems, HVAC, DHW systems, lighting , heat exchangers, fans and pumps, automatic control systems, monitoring systems

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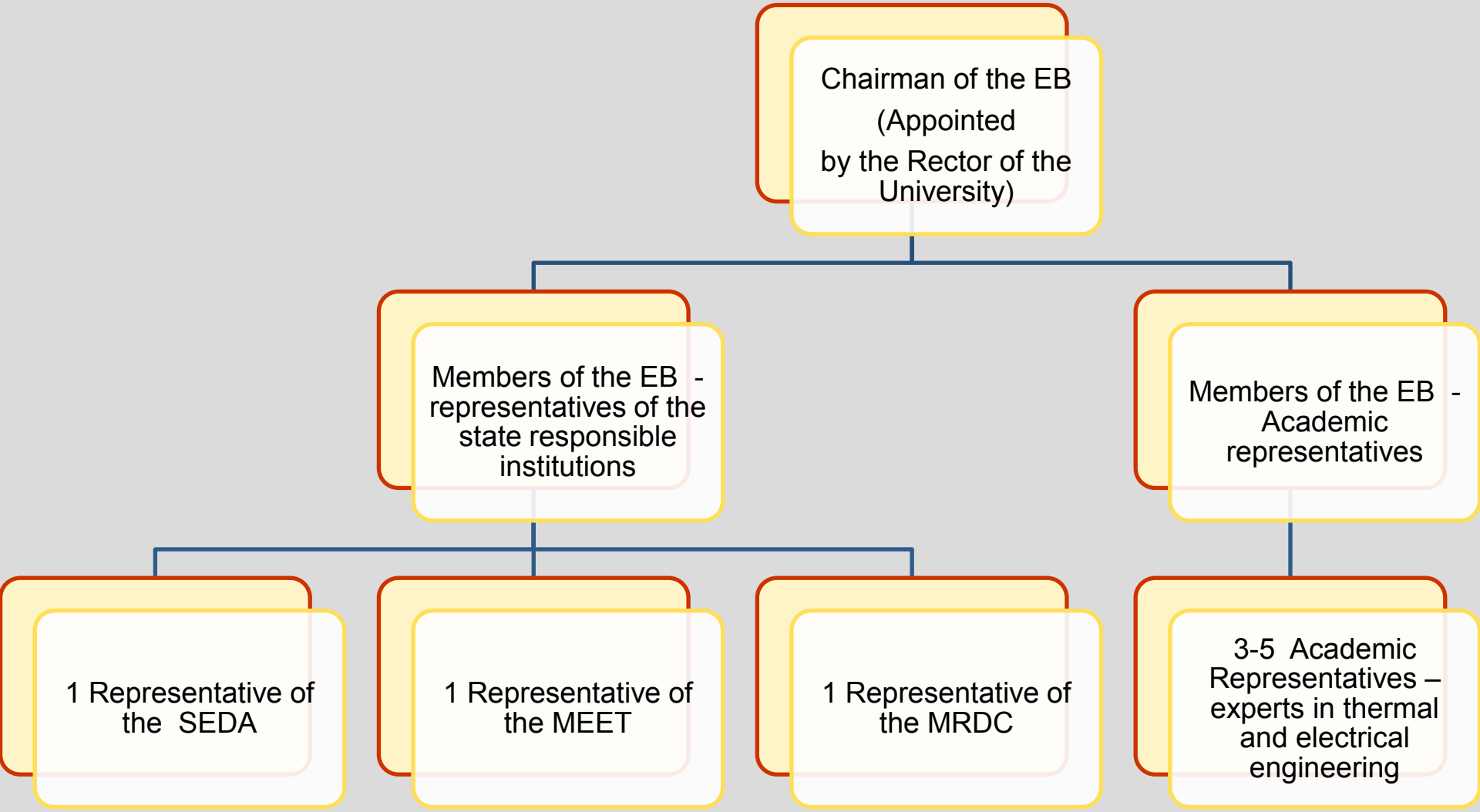
Structure of the Examination Board



THE LATEST DEVELOPMENTS

TOWARDS "nearly Zero-Energy Buildings"

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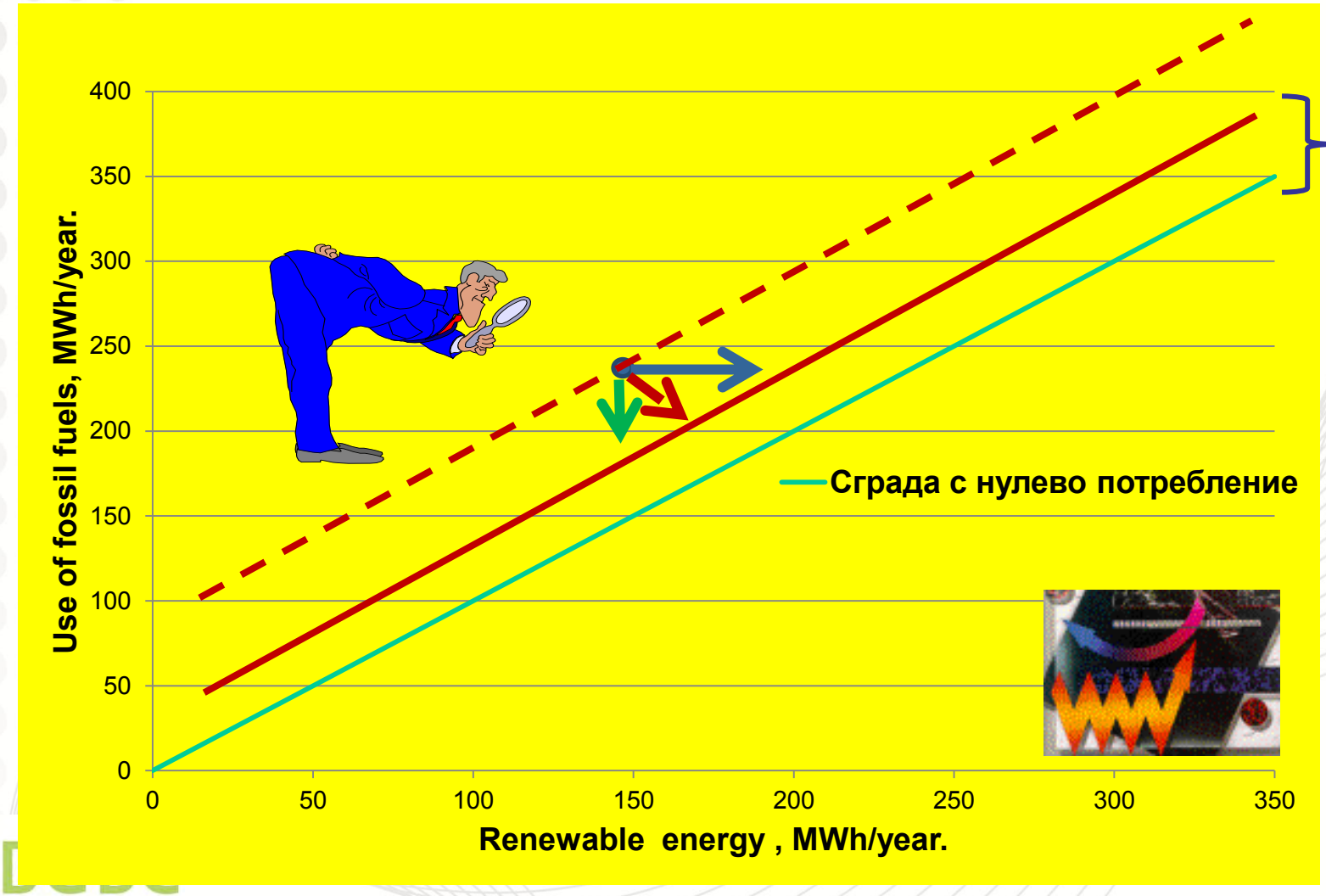
“ZEB” → „nZEB”



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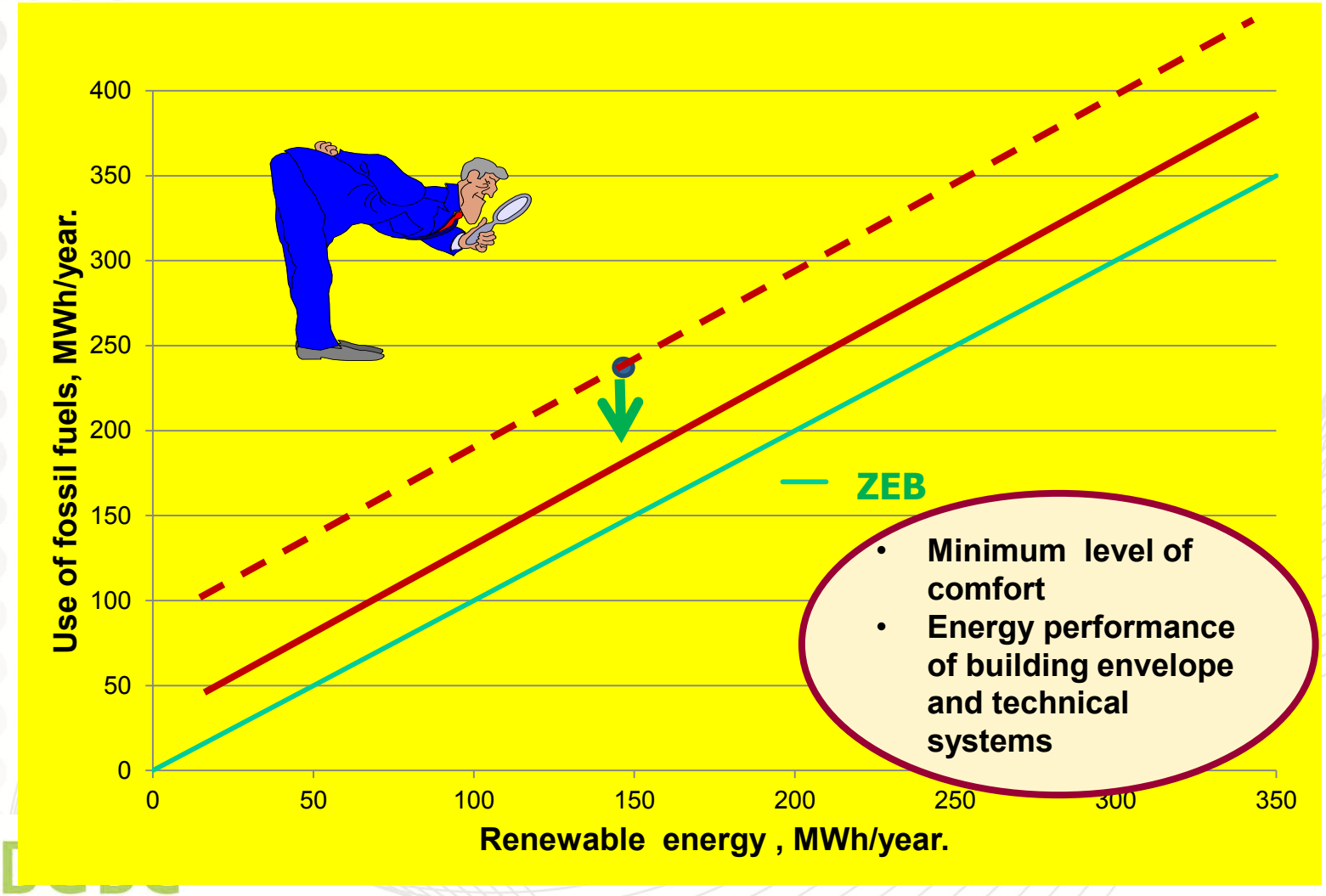
1 ENERGY DEMAND



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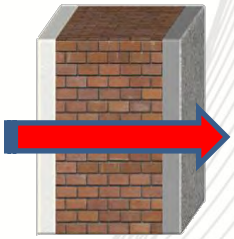
1 ENERGY DEMAND

U_{min} , U_{max}
W/m^2K
walls



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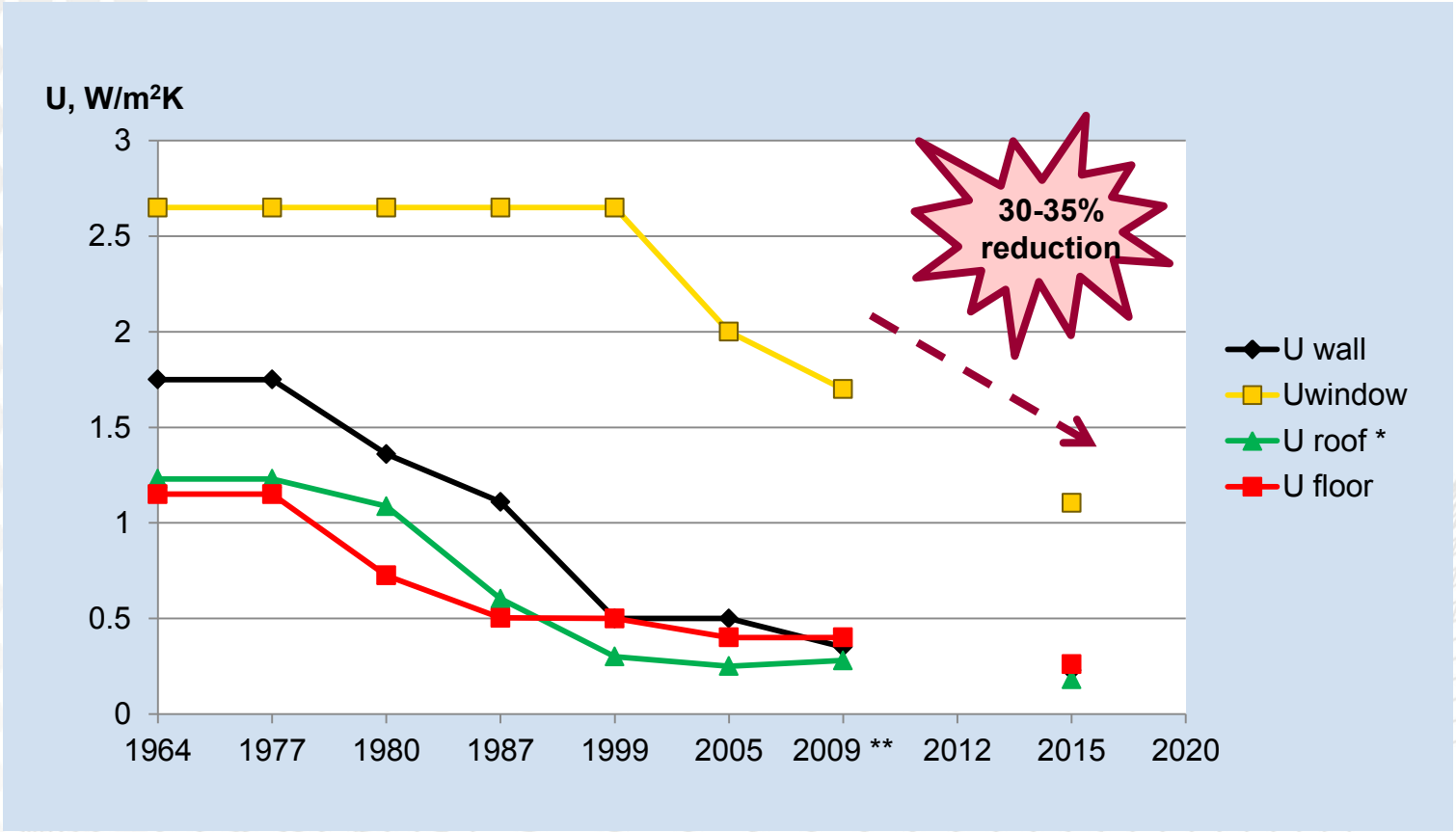
1 ENERGY DEMAND



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1 ENERGY DEMAND

No	Описание					LT	LR	ET	EA	g	U	Rw	Дебелина	Тегло	Среден интензитет на пълното слънчево греене		Изчислителна външна температура		Температурна разлика при вътрешна температура 20˚C	
	Външно	Дист.	Средно	Дист.	Вътрешно	%	%	%	%		W/m2.K	dB	mm	kg	Януари	Юли	Зима	Лято	Зима	Лято
1	ФЛ4	16	НЕ 4			80	12	55	19	62	1.4	29 (-1;-4)*	24	20	21.2	82.7	-17	37	37	17
2	ФЛ4	16аргон	НЕ 4			80	12	55	19	63	1.1	29 (-1;-4)*	24	20	21.2	82.7	-17	37	37	17
3	Сол 4	16	ФЛ4			65	26	41	22	43	1.3	29 (-1;-4)*	24	20	21.2	82.7	-17	37	37	17
4	Сол 4	16 аргон	ФЛ4			65	26	41	22	43	1	29 (-1;-4)*	24	20	21.2	82.7	-17	37	37	17
5	НЕ 4	12 аргон	ФЛ4	12 аргон	НЕ4	71	15	42	27	50	0.7	32 (-1;-6)**	36	30	21.2	82.7	-17	37	37	17
6	НЕ 4	16 аргон	ФЛ4	16 аргон	НЕ4	71	15	42	27	50	0.6	32 (-1;-6)**	44	30	21.2	82.7	-17	37	37	17
7	Сол4	12 аргон	ФЛ4	12 аргон	НЕ4	59	29	33	27	39	0.7	32 (-1;-6)**	36	30	21.2	82.7	-17	37	37	17
8	Сол 4	16 аргон	ФЛ4	16 аргон	НЕ4	59	28	33	27	39	0.6	32 (-1;-6)**	44	30	21.2	82.7	-17	37	37	17
9	Сол4	16 аргон	ФЛ4	16 аргон	Сол4	49	35	26	30	33	0.5	32 (-1;-6)**	44	30	21.2	82.7	-17	37	37	17
															Север		в ˚С	в ˚С	в ˚С	в ˚С
4	Сол 4	16 аргон	ФЛ4			65	26	41	22	43	1	29 (-1;-4)*	24	20	36.8	124.9	-11	34	31	14
															Изток/Запад		в ˚С	в ˚С	в ˚С	в ˚С
4	Сол 4	16 аргон	ФЛ4			65	26	41	22	43	1	29 (-1;-4)*	24	20	66.3	104.7	-11	34	31	14

Extensive research with the Bulgarian Association for windows and doors about the thermal and economic parameters of window's structures.

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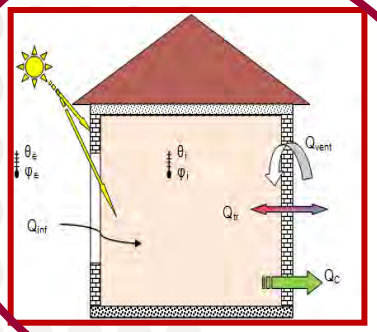
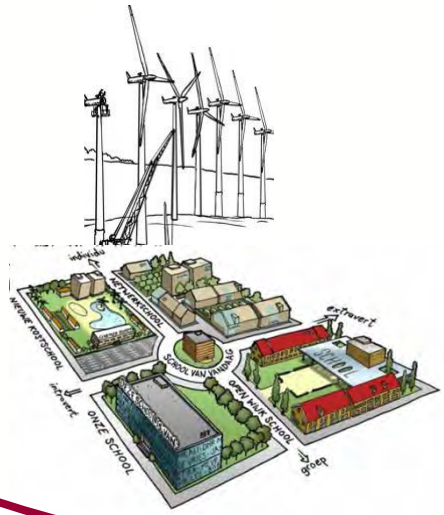
2 RES SHARE

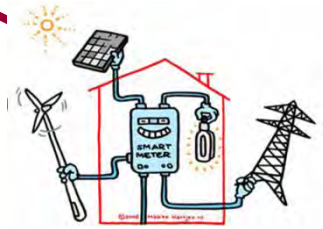
LEVELS OF RES ENERGY

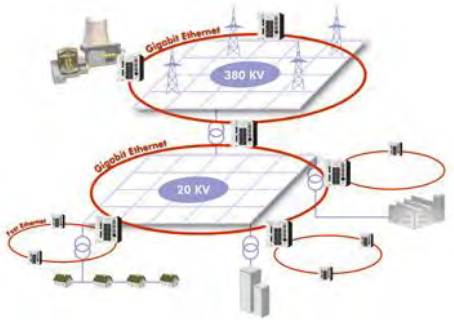


Building level



Local level





Infrastructural level

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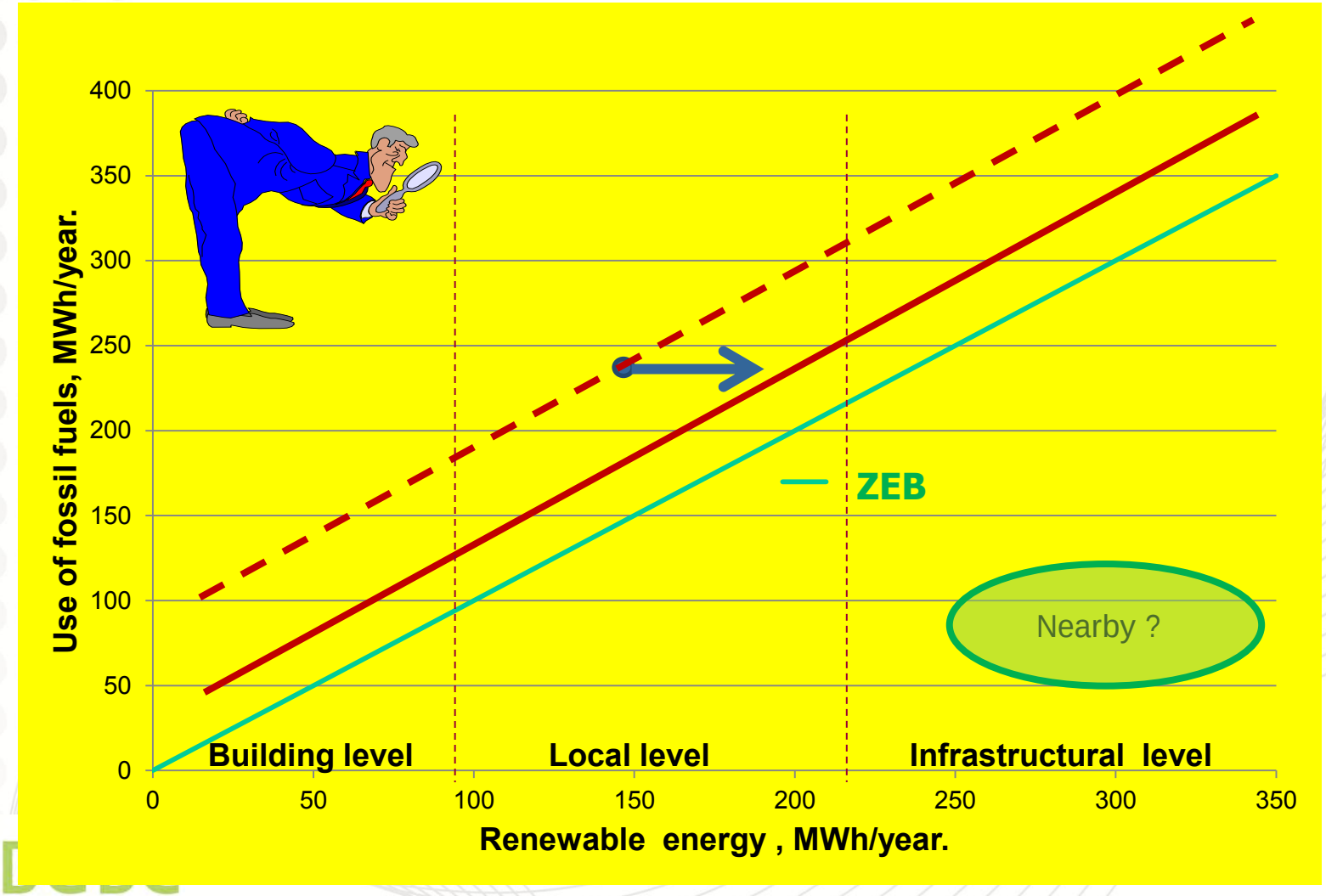
2 RES SHARE



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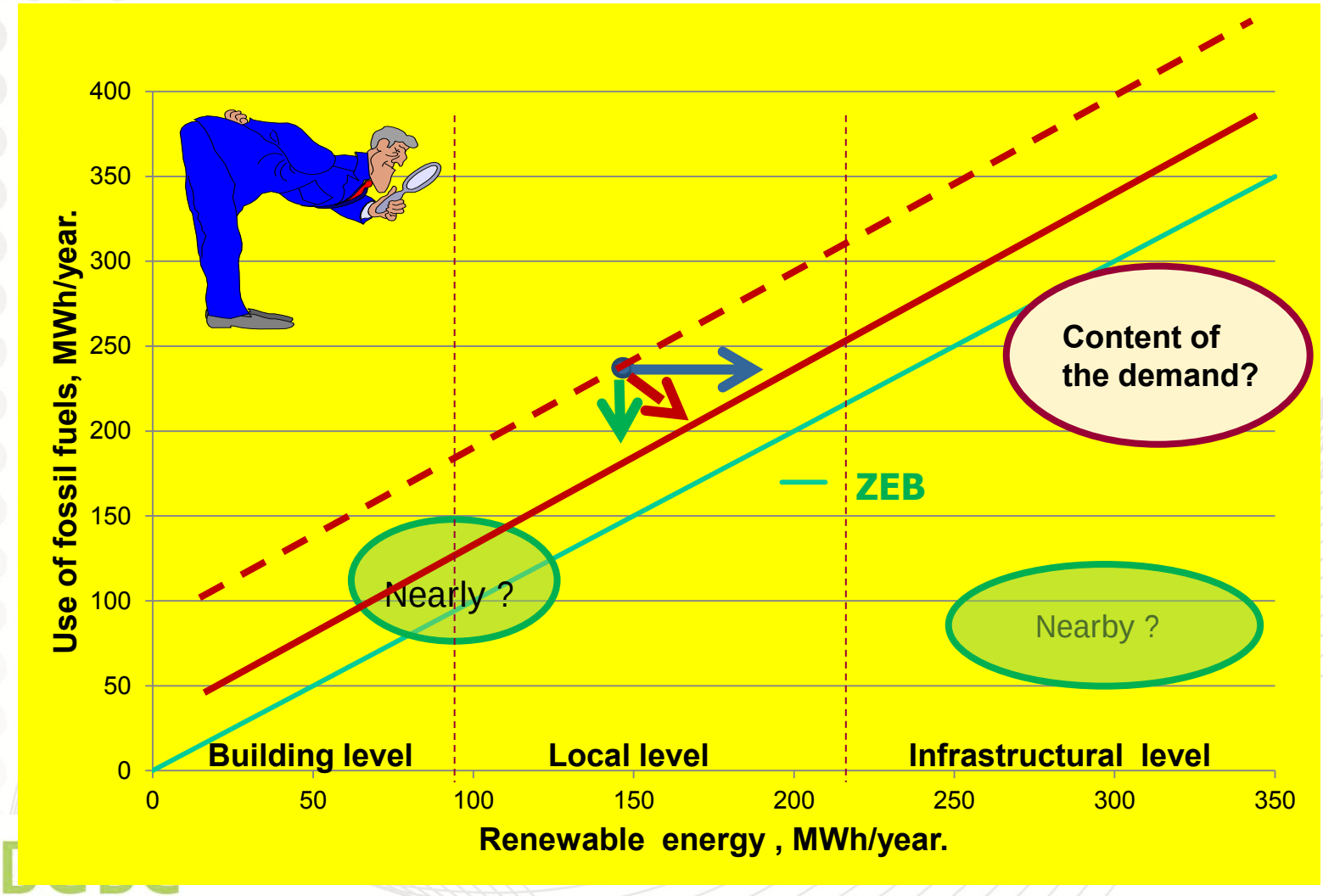
2 RES SHARE



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BALANCE : ENERGY DEMAND - RES ?

nZEB implication:

- **A threshold for maximum energy demand could be defined as:**
  - **Upper limit : by applying cost-optimal procedure for finding cost – optimal level**

- **A threshold for minimum renewable share:**
  - **More than 50%**

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3 nZEB ~ nZCB

- EPBD aims to nZCB
- EU climate goals indicate the need of nZEB ~ nZCB
- There is a need for energy indicator linked to CO_2 emissions which is independent of climate.

nZEB implication:

- Energy performance indicated in primary energy,
- CO_2 emissions can be added as supplementary information,
- BG national final to primary energy conversion factors must be updated and should reflect the reality.

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Comparative analysis – 31 countries

Structure of national applications of the NZEB definition: Status 20/06/12

Country		A	B-BR	B-FL	B-W	BG	CR	CY	CZ	D	DK	EE	ES	FI	F	GR	HU	I	IR	LV	LT	LX	MT	NL	N	PL	PT	RO	SL	SK	S	UK	Total/Ø
State of application	Offic. approved		X								X																						2
	Developed	X							X			X			X				X												X		6
	Study performed			X				(X)		X							X				X												4
	Work ongoing			X	X	X	X	X		X				X		X		X	X	X		X		X		X	X		X	X		X	17
	Study planned												X										X		X			X					4
Included energy aspects	Annex I: H, C, V, DHW, L (non-res.)	X	X	X		X	X	X	X	X	X		X	X	X		X		X	X	X	X	X	X	X	X		X	X	X	X	X	27
	1+ aspects missing																										X						1
	Additional aspects							X	X			X											X		X				X			X	7
Used indicators	Primary energy	X	X	X	X		X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X		X	X	X	X	X			24
	Other	X							X	X			X	X					X	X	X	X			X				X	X	X	X	14
Type of requirement	Fixed value(s)	X	X				X	X	X	X				X	X		X		X				X	X	X	X	X		X	X	X		X	19
	Fixed + allowances					X					X	X						X				X			X				X				7
	Technology set								X	X							X				X	X	X									X	7
Renewable requirement	Ratio					X		X		X								X				X			X				X	X			8
	Minimum			X		X		X	X						X				X		X					X	X						9
	Non	X	X								X	X		X			X		X					X								X	8
Renewable inclusion (generation)	On building		X	X		X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X			X	X	X	X		X	24
	On-site		X	X		X	X	X	X	X	X	X	X			X	X		X	X	X	X	X	X			X			X		X	22
	Nearby			X			X			X	X		X			X	X		X		X	X	(X)	X			X			X		X	14
	Green certificates																		X					X									2
	Self-consumed			X		X		X	X	X							X		X	X		X	X	X					X	X			13
	Fed-in							X	X			X			X		X		X				X					(X)				X	8
	Only up to building's energy use								X	X	X			X	X							X				X							8
Size	Single building	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	30
	Building complex										X		X				X	X	X	X		(X)		X			X					X	8
NZEB application approach	Based on current requirements	X	X	X	X	X		X	X	X	X	X	X	X			X	X	X			X			X	X		X	X	X	X	X	22
	New approach										X				X		X		X	X	X	X										X	8
Tightening ratio [%]				60		35			40	40	34				60		35		70			70		25		70	25-50	20		75			47.1

THANK YOU!

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