



Business and Technical Concepts of Deep Energy Retrofit of Public Buildings

IEA EBC Annex 61

Subtask A Modelling Exercise from Estonia

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Studied building



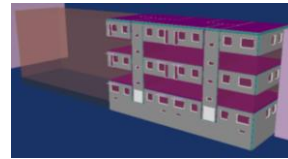
- Public housing (dormitory)
- Prefabricated concrete large panel elements

Number of floors	5
Net area, m ²	3519
Heated area, m ²	2968
Number of apartments	60
Compactness: Building envelope, m ² / volume, m ³ , m ⁻¹	0.35

- Natural passive stack ventilation
- District heating and one-pipe radiator heating systems
- The thermal transmittances of the building envelope of studied building types are:
 - External walls: $U_{\text{wall}} \approx 0.8\text{--}1.2 \text{ W}/(\text{m}^2 \cdot \text{K})$;
 - Roof-ceilings: $U_{\text{roof}} \approx 0.7\text{--}1.1 \text{ W}/(\text{m}^2 \cdot \text{K})$;
 - Windows: $U_{\text{window}} \approx 2.9 \text{ W}/(\text{m}^2 \cdot \text{K})$ designed to be air leaky
 - The building envelope contains structural thermal bridges.



Simulation methods



- Energy and indoor climate multi-zone modelling
- Climate zone, 6A: design temperature $-21\text{ }^{\circ}\text{C}$, annual heating degree days at $t_b\ 17^{\circ}\text{C}$: $4160\text{ }^{\circ}\text{C}\cdot\text{d}$
- Internal heat gains were as follows:
 - People: $15.8\text{ kWh}/(\text{m}^2\cdot\text{a})$. Heat from people is counted from $3.0\text{ W}/\text{m}^2$ and $80\text{ W}/\text{person}$ using ISO 7730 standard (1.2 met, 0.7 clo);
 - Appliances, equipment: $15.8\text{ kWh}/(\text{m}^2\cdot\text{a})$. Heat from appliances and equipment is counted using $3.0\text{ W}/\text{m}^2$ and the usage rate is 0.6;
 - Lighting: $7.0\text{ kWh}/(\text{m}^2\cdot\text{a})$. Heat from lighting is counted using $8\text{ W}/\text{m}^2$ and the usage rate is 0.1.
- Ventilation airflow is $0.35\text{ l}/(\text{s}\cdot\text{m}^2)$ (indoor climate category III)
- Domestic hot water: $520\text{ l}/(\text{m}^2\cdot\text{a})$ / $30\text{ kWh}/(\text{m}^2\cdot\text{a})$, approximately 35–45 l / (pers. \times day) depending on the density of living



Economic calculations



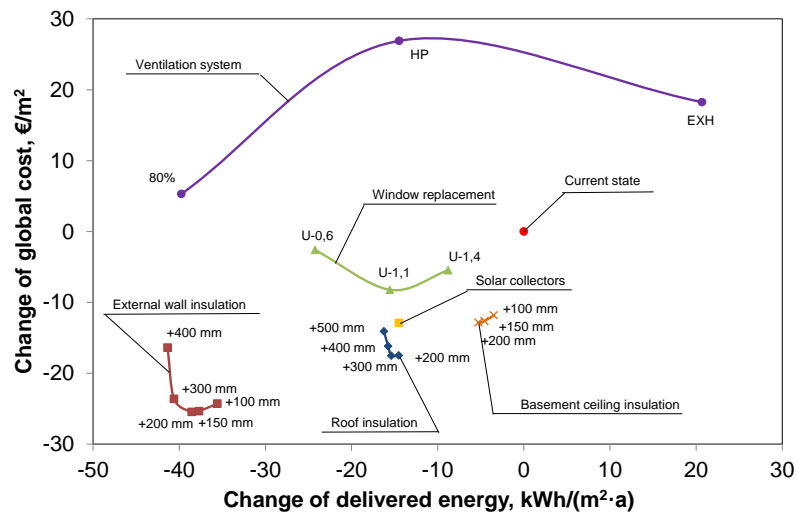
- Energy cost:
 - district heating 0.075 €/kWh ;
 - electricity 0.14 €/kWh .
- The global cost of 20 years $C_g(\tau) = \frac{C_i + \sum_{j=1}^{20} (C_{ai}(j) \times R_d(j))}{A_{floor}} - \frac{C_g^{ref}}{A_{floor}}$
- Construction costs (2012...2013 year's data)
 - additional insulation for external walls, €/m^2
 - additional insulation for flat roof, €/m^2
 - additional insulation for basement ceiling, €/m^2
 - replacement of windows, €/m^2
 - renovation of heating system, €/m^2
 - renovation of ventilation system, €/m^2
 - renewable energy systems, €/MWh

Renovation scenarios



- Scenario 1: Baseline (current state).
 - some minor energy saving measures,
 - 2/3 of windows replaced ($U_{\text{window (glass/frame)}}$, 1.8/2.0 W/(m²·K))
 - some walls have been insulated (50...100mm)
- Scenario 2: minor renovation (1995...2005)
- Scenario 3: major renovation (2010)
 - Energy Certification Class “D”: PE ≤ 180 kWh/(m²·a)
 - Decrease of delivered energy ≈33%
- Scenario 4:
 - New building: ECC „C“
PE ≤ 150 kWh/(m²·a) -50%
 - Low-energy building: ECC „B“
PE ≤ 120 kWh/(m²·a) -60%

Individual measures



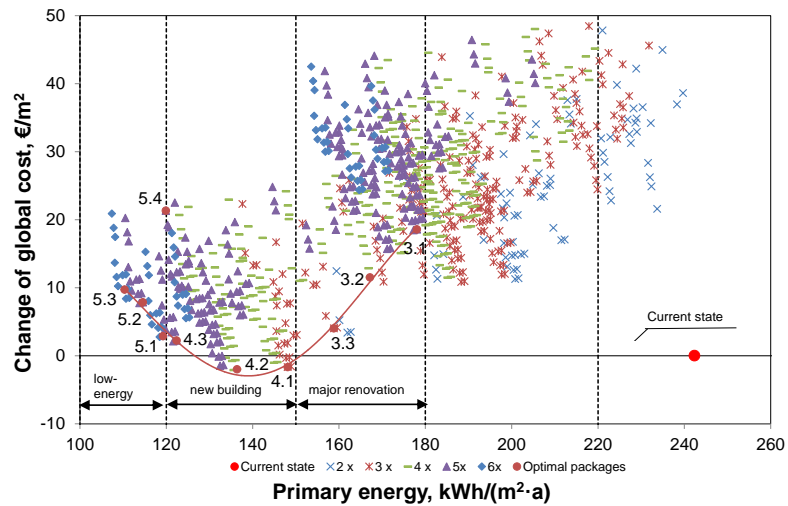


Renovation packages

Energy saving level, and renovation package	NPV, €/m ² (20 year)	Investment, €/m ²	Delivered energy, kWh/(m ² ·a) / decrease from base case, %	Primary energy, kWh/(m ² ·a) / decrease from base case, %	Energy-renovation measures																
					Windows			External walls		Roof		Base floor	Ventilation			DH W					
					W1.4	W1.1	W0.6	EW150mm	EW200mm	EW400mm	R300mm	R500mm	BF100	EXH	HP	VHR80	Solar collectors				
Current state	288		233	242																	
Scenario 3: major renovation	Vers. 3.1	307	109	156 / -33%	178 / -26%	x			x			x			x	x					x
	Vers. 3.2	300	115	142 / -39%	167 / -31%							x	x						x		x
	Vers. 3.3	292	117	133 / -43%	159 / -34%				x					x					x		
Scenario 4: new building	Vers. 4.1	286	124	121 / -48%	148 / -39%				x			x							x		
	Vers. 4.2	286	138	107 / -54%	136 / -44%				x			x							x		x
	Vers. 4.3	290	159	92 / -61%	122 / -50%	x			x			x							x		x
Scenario 5: low-energy building	Vers. 5.1	291	163	90 / -61%	119 / -51%	x			x			x			x				x		x
	Vers. 5.2	296	174	83 / -64%	115 / -52%				x	x		x							x		x
	Vers. 5.3	298	181	81 / -65%	110 / -55%				x	x			x	x					x		x
	Vers. 5.4	309	181	90 / -61%	120 / -50%				x			x		x					x		

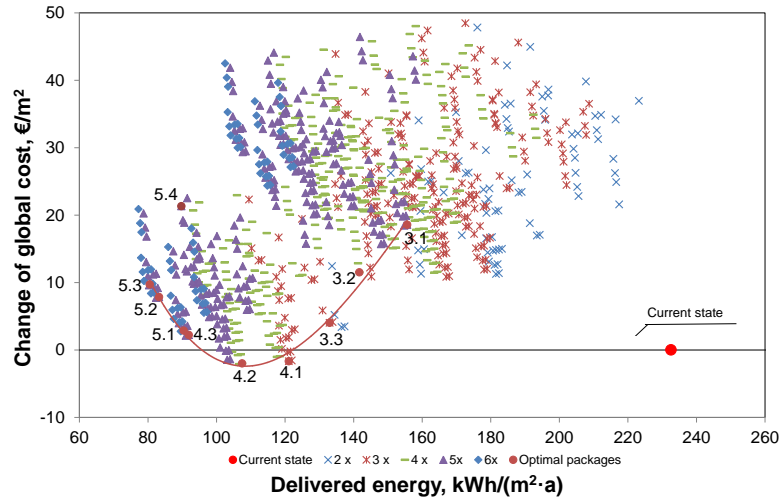


Primary energy: ECC

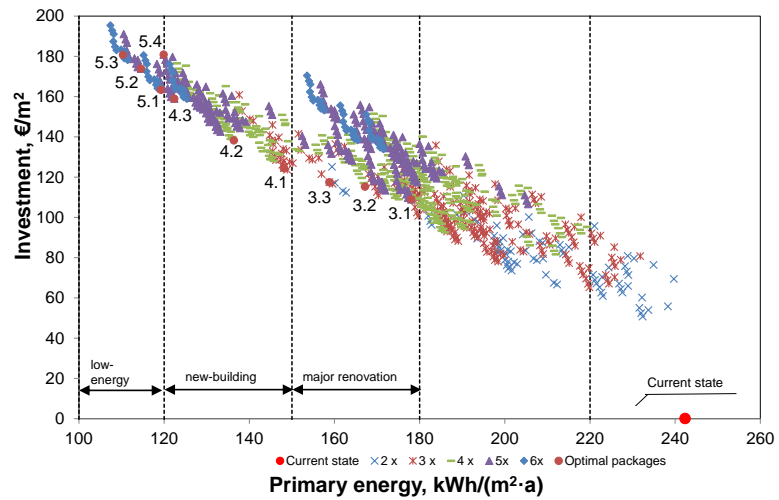




Delivered energy



Investments





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