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Lithuanian Case Study

Part III: Cost-benefit study of energy efficiency measures

3.11. Budget of the improvement alternatives

Improvement 1: Improved thermal envelope + triple glassed windows

Description of the price of the insulation system of the building facades for the exterior:

Item	Cost (€ / m²)
Rock wool insulation (25 cm)	€25
Adhesive, anchors, mesh, profiles	€8
Plaster finish (multi-layer)	€6
Labor (installation)	€15
Scaffolding & safety (5-story building)	€4
Total Estimated Cost (Installed)	**€58 per m²**

Description of the new windows to be installed in the building.

- Glazing: Triple glazing (3 panels)
- Coating: Low-emissivity (Low-E) on at least one pane
- Gas fill: Argon gas between panes (for thermal insulation)
- Frame: uPVC with thermal break
- Installation: Retrofit in existing wall opening (including sealing, trim, disposal of old window)

Improvement 1 budget:

Improvement 1: Thermal envelop isolation and new windows

Unit	Description	n.	measurement	price €	amount €
m2	25 cm mineral wool isolation layer in facades with plaster finish installed	1	900,8	58,00 €	52.246,40 €
m2	Low emissive triple-glazed PVC windows with argon gas (U= 0.8 W/m²·K)	1	407,57	420,00 €	171.179,40 €
				Total	**223.425,80 €**

- Improvement 2: Mechanical ventilation with heat recovery

Technical Specifications of the ventilation system:

Item	Description
Total ventilation capacity required	1.47 m³/s (5,292 m³/h)
System includes	2 fans, 70% heat recovery unit, full ductwork, insulation, controls
Building type	Existing 5-story residential building, 600 m²/floor
Estimated total cost (Lithuania)	€ 42.500,00
Energy savings	~50–60% savings in heating energy vs. simple exhaust system

Improvement 2: Mechanical Ventilation system with heat recovery

Component	Description	Estimated Cost (€)
2 Fans (1.47 m^3/s total, 750 W/(m^3/s))	High-efficiency EC fans, variable speed	4.000,00 €
Heat Recovery Unit (≥70% efficiency)	Sensitive plate or rotary exchanger	6.000,00 €
Ductwork and Air Diffusers (approx. 300 m)	Galvanized steel ducts, dampers, grilles	14.000,00 €
Insulation for ducts	Thermal + acoustic (mandatory for HRV systems)	3.000,00 €
Control system + sensors (CO_2, temp, etc.)	Smart automation, demand control	3.000,00 €
Installation (retrofit complexity)	Cutting, ceiling routing, labor intensive	10.000,00 €
Engineering project & permits	Design, balancing, legal compliance	2.500,00 €
TOTAL ESTIMATED COST	Turnkey mechanical ventilation system	**42.500,00 €**

Improvement 3: Ground heat pump for DHW

Improvement 3: Geothermal heat pump + hot water tanks + boreholes + internal distribution

Component	Description	Estimated Cost (€)
Geothermal Heat Pump (20 kW)	High-efficiency unit for DHW	14.000,00 €
Hot Water Storage Tanks (3000 liters)	Storage for peak demand	6.000,00 €
Vertical Boreholes (4 × 100 m)	Drilling, piping, antifreeze, connection	20.000,00 €
Hydraulic System (pumps, valves, controllers)	Includes expansion tanks, valves, sensors	5.000,00 €
DHW Internal Piping (5-story building)	Insulated pipes, distribution network	10.000,00 €
Installation and Commissioning	Labor, insulation, testing	10.000,00 €
Engineering Project and Permits	Design, documentation, local approvals	3.000,00 €
TOTAL ESTIMATED COST	Complete turnkey system	**68.000,00 €**

Improvement 4: Photovoltaic panels

Technical Specifications of the Photovoltaic panel system:

Location: Lithuania
Building: 5-story existing structure
System Specifications:

- Number of Panels: 150
- Panel Capacity: 480 W each
- Total Capacity: 72 kWp
- Estimated Annual Production: 71,250 kWh

Improvement 4: Photovoltaic panels

Component	Estimated Cost
Total System Capacity	72 kWp
Cost per kWp	€850
Total Installation Cost	**€61,200**

3.12. Cost-benefit study of energy efficiency measures

A cost-benefit analysis (CBA) in the context of building energy renovation is a structured evaluation used to determine whether the investment in upgrading a building's energy performance is economically justified.

It compares all expected costs of the renovation against the financial and non-financial benefits it will generate over the building's lifecycle.

In this case study, the *CypeTherm Improvement plus* software has been used to perform this analysis.
In this study, two methods have been used to carry out this analysis:

- Simple Payback Period (SPP)
- Net Present Value (NPV)

Method 1: The **Simple Payback Period** is one of the most straightforward methods for evaluating the financial return of an investment in energy efficiency, such as the energy renovation of a building.

The Simple Payback Period (SPP) is the amount of time (typically expressed in years) it takes for the cumulative energy cost savings generated by an investment to equal the initial cost of that investment.

$$\text{SPP} = \frac{\text{Initial Investment Cost}}{\text{Annual Energy Savings}}$$

Method 2: The **Net Present Value** method is one of the most widely used and robust financial tools for evaluating the profitability of an investment over time. In the context of building energy renovation, NPV helps determine whether the long-term energy savings and other benefits outweigh the initial costs of the retrofit.

NPV is the sum of all future cash flows (such as energy savings, maintenance savings, or subsidies), discounted back to their present value, minus the initial investment cost.

It accounts for the time value of money, recognizing that money received (or saved) in the future is worth less than money today.

$$NPV = \sum_{t=1}^{n} \frac{B_t - C_t}{(1+r)^t} - I$$

Where:

- B_t = Benefits (e.g., energy savings) in year *t*
- C_t = Operating or maintenance costs in year *t*
- r = Discount rate (interest rate or cost of capital)
- t = Year (1 to *n*)
- *I* = Initial investment cost
- n = Analysis period (in years)

If NPV > 0 → The investment is profitable

If NPV = 0 → The investment breaks even

If NPV < 0 → The investment is not financially viable

Energy cost considered:

Energy cost

Energy vector		
Electrical grid energy	0.30	EUR/kWh
Natural gas	0.11	EUR/kWh
Diesel	0.10	EUR/kWh
LPG	0.15	EUR/kWh
Carbon	0.05	EUR/kWh
Solid biomass	0.11	EUR/kWh
Biomass	0.11	EUR/kWh
Thermal solar energy	0.00	EUR/kWh
Electrical energy produced by photovoltaic panels, small wind turbines and small hydro turbines	0.00	EUR/kWh

Parameters for the Net present value method:

Net Present Value

☑ NCV calculation method

The program uses the static analysis method to calculate the investment recovery period. By activating this option, the dynamic analysis will be included in the calculation process.

Annual energy cost increase	3.00	%
☑ Discount fee	4.50	%
Foreseen inflation	1.20	%
Nominal interest type	0.00	%
Analysis period	22	Years

Summary of the results of the Cost-Benefit study of energy efficiency measures:

	Net cost of the investment (EUR)	Annual energy cost (EUR)	Annual net savings (EUR)	Payback (year)	NCV (year)	Annual consumption of non-renewable primary energy (kWh/m²)	Emissions (kg CO2/m²)
Initial situation	0.00	56977.73	0.00	0.00	0.00	137.63	29.90
Case 2: Imp 1 Thermal envelope	223425.80	44773.87	12203.86	18.31	20.17	107.70	23.58
Case 3: Imp 2 Mechanical ventilation HR + case 2	265925.80	37311.48	19666.25	13.52	14.72	90.43	19.53
Case 4: Imp 3 Ground heat pump for DHW + case 3	360385.80	31668.47	25309.25	14.24	15.54	82.42	15.60
Case 5: Imp 4 Photovoltaic panel + case 4	395125.80	17973.56	39004.17	10.13	10.86	44.65	9.22

In the table above, the NCV column answers the following question: How many years will it take to recover the investment, considering the time value of money?

	Net investment cost				Annual net savings				Investment recovery period (year)
	Cost (EUR)	Grants (EUR)	Resultant net cost (EUR)	Difference (EUR)	Energy cost (EUR/year)	Energy savings (EUR/year)	Maintenance (EUR/year)	Net savings (EUR/year)	
Initial situation	0.00	0.00	0.00	0.00	56977.73	0.00	0.00	0.00	0.00
Case 2: Imp 1 Thermal envelope	223425.80	0.00	223425.80	223425.80	44773.87	12203.86	0.00	12203.86	18.31
Case 3: Imp 2 Mechanical ventilation HR + case 2	265925.80	0.00	265925.80	265925.80	37311.48	19666.25	0.00	19666.25	13.52
Case 4: Imp 3 Ground heat pump for DHW + case 3	360385.80	0.00	360385.80	360385.80	31668.47	25309.25	0.00	25309.25	14.24
Case 5: Imp 4 Photovoltaic panel + case 4	395125.80	0.00	395125.80	395125.80	17973.56	39004.17	0.00	39004.17	10.13

4. Conclusions

The following conclusions can be drawn from this study:

- **Comprehensive Building Assessment Completed**. The case study thoroughly evaluated the current energy performance of a multi-story dormitory building in Lithuania, using BIM technologies, identifying major inefficiencies in envelope insulation, window performance, DHW systems, and ventilation. The building was characterized by high energy consumption and poor thermal comfort, especially during the heating season.
- **Energy Efficiency Measures Identified and Modeled.** A wide range of energy renovation measures were proposed and simulated, including:
  - External wall insulation. (The roof was already isolated in 2014)
  - Replacement of windows.
  - Domestic hot water system modernization (by mean of ground heat pump system)
  - Mechanical ventilation with heat recovery
  - Integration of rooftop photovoltaic (PV) panels
- **Substantial Energy and CO_2 Savings Potential.** The analysis showed that implementing a combination of passive and active measures could reduce non-renewable primary energy consumption by more than 67% and CO_2 emissions by over 70%. These savings are particularly significant given Lithuania's cold climate and long heating season.
- **Cost-Benefit Results Vary by Measure.** The financial assessment revealed that:
  - Deep renovation strategies (insolation, window replacement) require higher investment but offer long-term returns.
  - DHW system modernization and the new mechanical ventilation reduce energy losses due to the old existing systems.
  - PV panels contribute significantly to decarbonization goals.
  - If all the measures considered in the study are implemented, the payback period is considerably reduced (10 years) since greater energy savings are achieved.
- **Combination of Measures Yields Best Results.** The most balanced and sustainable outcome is achieved by combining passive improvements (insulation, airtightness) with active systems (modern

DHW system and ventilation system, PV panels). This synergy maximizes energy savings keeping indoor comfort, and enhances the building's overall value.

- **Technical and Economic Feasibility Confirmed.** Despite initial investment barriers, the study confirms that energy renovation is technically viable and economically beneficial for the dormitory. Using metrics such as NPV and SPP, all measures show acceptable economic performance, especially if they are implemented at the same time.
- **Supports National and EU Renovation Goals.** The case aligns with the EU's Green Deal and Renovation Wave strategy, contributing to targets for carbon neutrality, energy efficiency, and healthier indoor environments in public and residential buildings.