Example

The economic viability appraisal of the building envelope efficiency improvement is calculated below. The improvement parameter is the gradual increase of the external wall insulation. The building is to be built in Thessaloniki, Greece. The economic viability appraisal was performed using the NPV method.

Location characteristics

Thessaloniki Lat: 40° 31’ 35’’ Long: 22° 58’ 40’’ Alt: 20m	
Annual average solar radiation on horizontal plane	1403 kWh/m^2
DD (heating)	1744
T average	January = , August=

Building description

The building used is a two-storey detached house with a total living area of 184m^2. Each storey has 92 m^2. There is also a non-heated basement which accommodates the heating plant, car parking space, and storeroom. Figure 1 shows the plan.

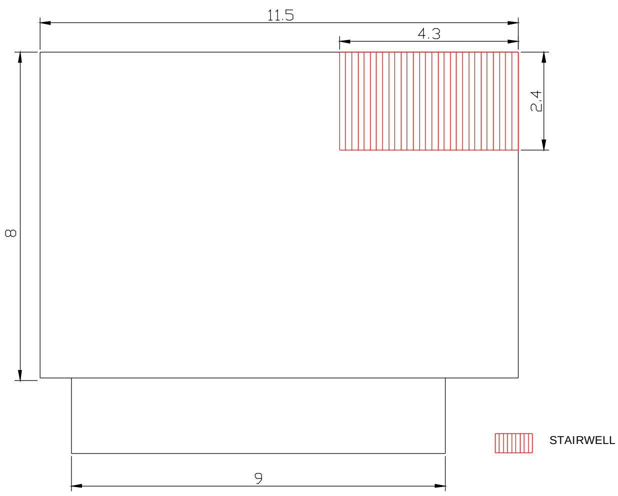


Fig 1 ‘Plan view of the typical floor

Building Envelope Data

Element	F (m^2)
Walls	146.4
Load bearing structure	72.4
Openings	23.3
Floor over non-heated basement	92
Roof	92
Total area of the building envelope (F)	426.1 m^2
Total Volume (V)	616.4 m^3

Table 1 Dimensions of building envelope components

The openings are oriented as follows:
74% due NW
13% due SW
13% due SE
Free gains from users and appliances (or cooling load depending on the season) = 5 kWh/m^2 per day.

Building thermal characteristics

Element	U (W/m^2K)
Walls	0.576
Load bearing structure	0.64
Openings	3.0
Floor over non-heated basement	0.6816
Roof	0.4988
Overall U-value	0.7652

Table 2 U-value of building envelope components

The heating and cooling needs were calculated by simulating the building performance all year round. Free gains from users and appliances (or cooling load depending on the season) were taken equal to 5 kWh/m^2 per day, [EN 832].
Heating and cooling systems are intermittently operated. The thermal conditions within the space were set as follows:

- Winter: from 7:00 to 22:00, thermostat setting at 20 ^oC. After 22:00, the temperature can drop to 17 ^oC.

– Summer: from 11:00 to 22:00, thermostat setting at 26 ^{o}C. After 22:00 the temperature can increase to 28 ^{o}C.

The demand in heating and cooling was converted into heating and cooling energy using the following assumptions:

– Heating is supplied by oil burning central heating system with an average efficiency over the life span of the system, equal to 80%. The calorific value of the fuel oil was taken equal to 11.9 kWh/lt.

– Cooling is supplied by split type air-conditioning systems with COP = 2.5.

The NPV was calculated for a series of increments of the insulation material thickness on the external walls (see Table 3).

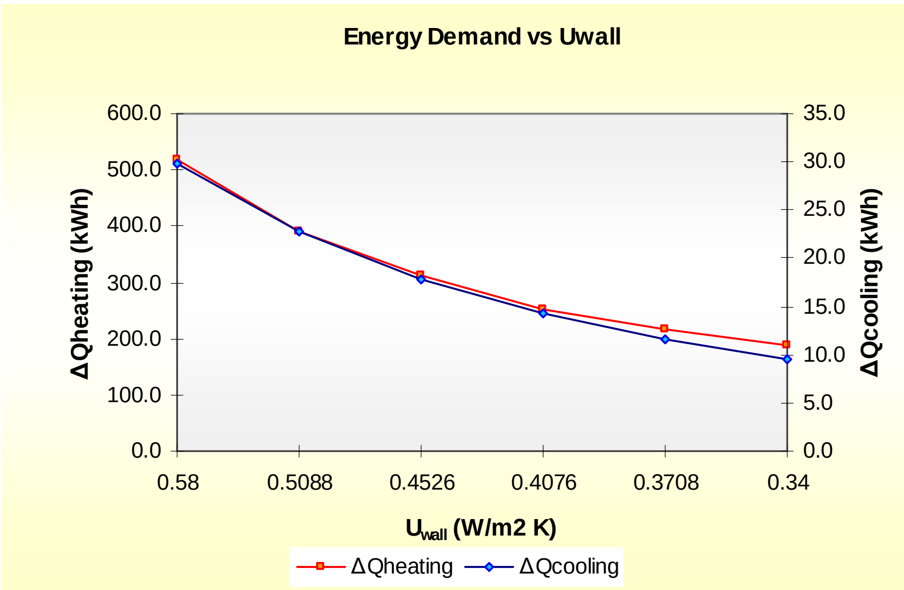
The assumptions made were the following:

1. Discounted interest rate 6% (over inflation rate)
2. Fuel oil price = 0.7 €/lt with an annual increase of 1%.
3. Electric energy price = 0.12 €/kWh with an annual increase of 1%.
4. Cost of insulation = 1.5 €/(cm of material thickness). This is the purchase cost of the material and represents an average value of an inexpensive and expensive one. Installation cost is omitted since it is the same as in the reference case.

The results are tabulated in Table 3 and 4 next page.

Conclusions

The net present value (NPV) has been calculated for 25 to 40 years. For the 25-year period, the NPV exceeds twice the investment for insulation thickness up to 8cm (U_{wall} =0.4076 W/m^2 K). When a 30-year period is taken into account then the NPV exceeds twice the investment for insulation thickness up to 9 cm. Regarding the energy savings pattern, the energy reduction rate is decreasing substantially when the U_{wall} becomes less than 0.4076 (W/m^2 K). This is shown in the following diagram.



Insulation thickness (m)	U_{wall} (W/m^2 K)	Heating energy requirements Qθ (kWh)	Insulation cost (€)	ΔQθ (kWh)	Extra Insulation cost (€)	Fuel oil savings (lt)	First year heating savings (€)	Cooling energy requireme (kWh)
0.04	0.677	11721	878.4					4112
0.05	0.58	11203	1098.0	518.1	219.6	54	38.10	4037
0.06	0.5088	10812	1317.6	909.4	439.2	96	66.87	3980
0.07	0.4526	10498	1537.2	1223.0	658.8	128	89.93	3936
0.08	0.4076	10246	1756.8	1474.7	878.4	155	108.44	3900
0.09	0.3708	10028	1976.4	1692.8	1098.0	178	124.47	3871
0.1	0.34	9841	2196.0	1880.3	1317.6	198	138.26	3847

Table 3 Impact of the wall insulation increment on energy savings and operational cost reduction

U_{wall} (W/m^2 K)	**NPV 40**	**NPV 30**	**NPV 25**
0.58	564.94	465.93	400.18
0.5088	941.17	767.34	651.90
0.4526	1,200.68	967.01	811.82
0.4076	1,368.15	1,086.44	899.35
0.3708	1,483.73	1,160.64	946.06
0.34	1,553.12	1,194.56	956.42

Table 4 Net Present Value for wall insulation increment