Technical-economic studies of energy rehabilitation solutions

Alejandro San Vicente Navarro

INDEX

Unit 1: Building evaluation: general information, envelope and facilities

1 Energy efficiency measures: definition and classification

The advantages of the implementation of energy efficiency measures can be summarized in three major action frameworks.

- **Reduction of external energy dependence**. Spain (and Europe) are importers of fossil energy sources such as natural gas or oil. By reducing this dependence, security of supply is also increased.
- **Reduction of production costs,** increasing the competitiveness of companies as well as reducing the final energy expenditure of households.
- **Reduction of environmental deterioration and promotion of sustainability**, due to the reduction of greenhouse gases from the combustion of fossil fuels that generate greater environmental pollution as well as a reduction in the consumption of perishable natural resources such as coal, natural gas or the oil.

The objective of energy efficiency is therefore the reduction of the consumption of non-renewable energy sources (C). To achieve this end, 3 different strategies are available:

- Decrease in energy demand (D)

- Increase in the performance of the facilities (R)

- Greater contribution of renewable energy sources (EERR)

It can be summarized in this formula that details what is intended to achieve:

$$C\ (Consumption of renewable energy) = \frac{D\ (Energy demand)}{R\ (Performance of the installations)} - EERR$$

> *Remember*
>
> *Energy efficiency or efficient use of energy allows optimizing production processes and reducing the consumption of primary energy from non-renewable sources to produce more goods and services and without prejudice to the conditions of habitability and comfort for human beings.*

Decrease in energy demand

The demand for energy is the amount of energy that a building needs so that inside a user can enjoy certain comfort conditions.

The set of measures that can be adopted to reduce this amount of energy has a lot to do with how to minimize the losses of heat (or cold) that occur in the building envelope.

The demand for energy will depend fundamentally on the insulation characteristics of the enclosures, dividing walls, roofs, screeds, windows, doors, thermal bridges, the orientation, the shadows of the building, the use of the building, the lighting... in definitive, of many factors.

Depending on the thermal demand, the power of the air conditioning equipment will be designed and calculated, so that a reduction in demand leads to a reduction in the final consumption of primary energy.

Increase in the performance of the facilities

If the demand for energy is maintained, the other possibility for reducing consumption is to increase the performance of the facilities that provide it.

In this way, the same final useful energy is obtained (which is used and needed by the consumer) with a lower amount of primary energy (used fuel).

Let's see an example. The higher performance of a combustion boiler allows to achieve the desired air conditioning temperature by the user, minimizing the fuel used to obtain it, and consequently, primary energy has been saved.

At present, there are different technologies that are very efficient in energy matters and in addition different energy saving measures can be developed to achieve the maximum performance of an air conditioning installation.

For example, special attention will be paid to the most common generating equipment such as the heat pump (for heating / cooling) and the combustion boiler (for heating and domestic hot water).

Contribution of renewable energies

To these two main measures of decreasing final energy consumption can be added a third option through the contribution of a fraction in renewable energy.

The use of clean or renewable technologies as a source of energy does not decrease the total primary energy consumption of the system. In this case, the final consumption of the building is not reduced, but the percentage coming from non-renewable energies based on fossil and perishable sources (such as coal, oil or natural gas), whose use is penalized by the increasingly demanding regulations environment in an attempt to preserve the future and make sustainable the increase in global energy demand.

Objectives 2020 European Union

Therefore, the source is simply changed to obtain energy but providing a series of advantages that go along the line marked by the 3 priority objectives set by the European policy on energy saving and efficiency (also known as the 20-20-20 strategy), which are:

- Reduction by 20% in the emission of Greenhouse Gases (GHG) below 1990 levels. Renewable sources do not emit GHG.

-Contribution of 20% to the final energy consumption of renewable energies.

- Reduction of 20% in primary energy consumption (energy saving and efficiency measures). Renewables, as has been said, do not reduce total consumption but non-renewable primary energy consumption, which is a parameter used, for example, for the energy rating of buildings.

Objectives 2030 European Union

Recently the European Union has already proposed the new objectives in terms of energy efficiency. Obviously they go in the same line as those proposed for the year 2020 and only mark stricter values.

In this case the new objectives are:

- Reduction by 40% in the emission of greenhouse gases (GHG) below 1990 levels. Renewable sources do not emit GHG.

- Contribution of 27% to the final energy consumption of renewable energies.

- Reduction of 27% in primary energy consumption (energy saving and efficiency measures). Renewables, as mentioned, do not reduce total consumption, but non-renewable primary energy consumption is a parameter used, for example, for the energy rating of buildings.

The possibility of increasing the contribution of renewable energies from 27% to 35% and reducing the consumption of primary energy from 27% to 40% is currently under parliamentary procedure.

Remember

The implementation of energy saving measures and the promotion of clean and renewable energies strengthens the main guidelines of the EU's energy policy, such as:

- Reduction of external dependence on the importation of fossil energy sources (such as natural gas or oil)

- Increase in the competitiveness of European energy markets

- Compliance with environmental regulations

2 Phases of study and decision making in the adoption of energy efficiency measures

Work phases

The initial objective of an energy rehabilitation project is to identify the possible measures to be adopted in a building obtaining the highest level of efficiency.

You can determine 6 phases in the integral development of this work:

- Energy audit
- Determination of pathologies and possibilities for improvement
- Evaluation: Solutions and advantages
- Study of economic profitability and financing
- Execution. Quality and guarantees
- Monitoring and maintenance

Audit phase

The energy audit will be a tool for study, inspection, analysis and search of results through which it is intended to characterize the energy dimension under study and optimize its operation through the improvement of global energy efficiency.

Through the energy audit of a building, the degree of energy efficiency of the building is exhaustively studied.

To carry out this process it is usual to use equipment such as consumption meters, thermographic cameras, blower-door systems...

The audit analyzes all elements of the building that consume energy, as well as the thermal envelope and the consumption habits of its tenants.

The main objectives that are intended to achieve with this energy diagnosis are the following:

- Compilation of data and execution of tests on the energetic behavior of the property.

- Evaluation of the general condition of the facilities and their energy use.

- Quantification, analysis and classification of energy consumption.

- Assessment of the environmental and comfort characteristics of the property in relation to current regulations (normally the CTE and the RITE)

Phase of determination of pathologies and possibilities of improvement

In this phase, it is intended to make a preliminary list with the possible and usual energy efficiency measures that will later be the object of study in order to carry out an intervention.

Among the most common groups of pathologies can be listed the following:

- DEFICIENT THERMAL INSULATION: Lack of insulation with energy losses, poorly dimensioned insulation, incorrect insulation installation.

- THERMAL BRIDGES: Constructive failures of slabs, windows, doors, sills, roofs, pillars ...

- RENEWAL OF UNCONTROLLED AIR: Unwanted air infiltration, inadequate ventilation.

- FACILITIES WITH LOW PERFORMANCE: Age of the installations, lack of periodic maintenance, design of defective calculation, irregularities.

- LIGHTING FACILITIES WITH LOW PERFORMANCE: Not very efficient lamps, dirty luminaires, poorly distributed light, little use of natural light, little automatic regulation...

- LACK OF SOLAR PROTECTIONS: Not contemplated in project of execution protections like cantilevers, slats, blinds, orientations...

- INFILTRATIONS OF WATER AND HUMIDITY: Lack of maintenance on deck, downspouts and / or facades, poor waterproofing, lack of adequate drainage and sanitation. Leaks from roof or façade, broken pipes, dampness by capillarity.

- CONDENSATIONS: Appearance of mold and fungi (windows, corners, cabinets, ceilings), water accumulation in frames and windows.

Evaluation phase: Solutions and advantages

Based on the results obtained in the energy audit, improvement actions are recommended to optimize energy consumption, based on their energy saving potential, ease of implementation, environmental criteria and the cost of execution.

It is therefore the development and technical analysis of measures to reduce energy consumption and increase the comfort of the property. It will be necessary to quantify, analyze and classify potential savings.

The characteristics of the building at the time of considering an energy rehabilitation are those that will determine the needs of each building and the level of action with which it must act, as well as the savings that can be obtained with each of them.

Depending on the previous list, improvement measures can be proposed in:

- IMPROVEMENT OF THE ENVELOPE: The objective is to reduce the energy demand of the building. The associated saving grows in function of the relation of the surface affected by the rehabilitation with respect to the total surface of the envelope, by means of the improvement of the blind parts and architectural holes in the façade and roof.

- FAÇADE INSULATION

- INSTALLATION OF ENERGY EFFICIENT CARPENTRY AND GLASSES

- INSULATION AND WATERPROOFING OF COVER

- SOIL TREATMENT AND BURIED AREAS OF THE PROPERTY
- IMPROVEMENT OF THE ENERGY EFFICIENCY OF THE FACILITIES
- LIGHTING EQUIPMENT
- INSTALLATIONS AND THERMAL EQUIPMENT WITH BEST PERFORMANCE AND LESS CONSUMPTION
- INSTALLATION OF CONTROLLED AIR RENOVATION
- LOW TEMPERATURE HEATING
- CONSUMER DELIVERIES
- CHANGE HEATING DISTRIBUTION
- IMPLEMENTATION OF RENEWABLE ENERGIES: Promote the diversification of sources and the implementation of renewable energies to reduce dependence on hydrocarbons since their use is always a measure of non-renewable primary energy saving and, therefore, a saving in emissions of CO2
- BIOMASS
- THERMAL SOLAR ENERGY FOR THE PRODUCTION OF ACS

- GEOTERMIA

- HEAT PUMPS AND AEROTERMIA

- PHOTOVOLTAIC

The study in this phase concludes with a proposal of an intervention methodology for the implementation of these measures with minimal interference in the normal use of the property.

Study phase of economic and financial profitability

Once the energy study of the saving measure to be implemented has been developed, an economic-financial analysis of the relationship between the cost of the proposed measures and the savings obtained to determine the most profitable solutions is carried out.

It is about knowing if the investment that must be made can be really recovered over time or if, on the contrary, the economic saving in the new scenario is not high enough to justify that initial investment.

Various types of economic indicators will be used (amortization period, annual gross yield, benefit / cost ratio, NPV, IRR, TRI ...) that will allow to know the profitability and viability of the rehabilitation project.

In the next unit, all these parameters will be treated in much greater detail, a fundamental objective of the course.

3 THE INFLUENCE OF THE EXECUTION AND MAINTENANCE OF BUILDINGS ON ECONOMIC PROFITABILITY

Phase of implementation of the measures

This phase is the one that ends with the execution of the proposed measure.

It is an essential part of the process since its correct execution will depend in some cases on the effective reduction of the primary energy consumption and an improvement of the comfort conditions for the inhabitants of the building.

For some of the measures proposed, the execution of the same is quite simple and, therefore, the final economic performance will not depend so much on the quality of the implementation.

For example, the replacement of lamps is not a complicated operation and does not require great guarantees of execution.

On the other hand, in other measures (especially those that require waterproofing, insulation or tuning) it will be essential, in order to obtain optimal final results, to monitor the quality of the execution as well as final guarantees in them.

This point will be vital since the results in terms of the reduction of final consumption can be greatly undermined by their poor execution.

For example, if the insulation of a roof is projected as a measure of energy saving, it will be necessary to monitor all the phases in the execution of the same. Any failure or final problem will suppose a deviation on the original calculations and, therefore, a loss of performance and a possible discomfort in the final client.

Monitoring and maintenance phase

The actions aimed at the energy rehabilitation of the building will reduce energy consumption, which will lead to significant savings in the energy bill.

The last phase in the implementation of energy efficiency solutions is the maintenance of the measures. The objective is, in this case, to ensure the sustainability of its results over time.

You can differentiate two types of systems:

- o **Monitoring:** Through sensors distributed throughout the building that measure temperatures, humidity, air currents, atmospheric pressure, structural (vibrations, cracks, inclination, convergence, etc.), safety and consumption. Based on the data obtained, corrective measures will be considered.
- o **Maintenance:** Integral management of the maintenance of each of the components of the building, both enveloping and facilities, to ensure the comfort of its inhabitants and preserve the properties of the building, preserving its value. The maintenance plans prevent deterioration, breakdowns and damages, reducing the number of incidents with a minimum global cost.

For example, the final performance of a boiler will depend vitally on the type of maintenance that has been carried out.

If the maintenance is bad or zero, the combustion efficiency will drop sharply, while if it is correct it will approach the nominal performance guaranteed by the manufacturer.

Unit 2: Economic profitability and energy efficiency

1. Economic parameters: basic concepts

After the energy audit phase, the determination of possible pathologies, and the selection of energy saving measures that are going to be implemented, the cost of the investment must be assessed.

> *This is the start of the energy rehabilitation process that consists of the economic analysis of the measure.*

Normally the main concern of the client when making an investment in energy efficiency is its economic cost. On many occasions, this short-term vision does not allow intuiting the possibilities that the reduction of energy consumption of our building offers in the future, allowing not only to recover the money invested, but even to generate returns that finance future reforms.

It is about knowing if the investment that must be made can be really recovered over time or if, on the contrary, the economic saving in the new scenario is not high enough to justify that initial investment.

> *It is very important to keep in mind that not all energy rehabilitation measures can be viable and economically profitable.*

Starting data

In order to carry out a complete study of the evolution of energy consumption and costs as well as its subsequent profitability analysis, prior knowledge of a series of intrinsic data to the building model is required.

The starting data that are fundamental to perform the economic profitability study are:

• Annual energy savings, as a result of subtracting the current consumption of the building from what it would have if we implemented energy measures.

• Cost of the fuels used in € / kWh of energy, as well as the forecast of the evolution of its price in the period of time studied.

Coste combustible	€/Kwh	% Incremento anual
Electricidad	0,170	6,00%
Gas natural	0,060	5,00%
Gasoil	0,096	5,00%
Fuel-oil	0,102	5,00%
GLP	0,120	5,00%
Carbón	0,130	4,00%
Pellets	0,053	2,50%
Biomasa (otro tipo)	0,380	1,00%
Energías renovables	0,000	0,00%

Fuel costs 2017 and annual rise estimate.

Own preparation and Ministry of Public Works

- Investment cost in the energy saving measures that are implemented in the building. For this, the first thing will be to have price lists of the equipment, materials and labor necessary to obtain as clearly as possible the total cost of the measure that is to be implemented.

• Internal rate of return to be obtained or discount rate. It is the% minimum profitability required for an investment, either because the capital is borrowed and the cost of bank interest must be assumed, or because it could have been decided to invest in another product that generates more profitability (this is what is called cost of opportunity). A normal value could be set by the% of interest that the bank provides for a fixed-term deposit or for the value of Treasury Bills. That is, for the performance of a safe investment in the medium or long term.

• Maintenance expenses associated with the new energy measures.

• Estimated useful life of the measure to be applied in years.

With this basic investment start data, we will proceed to assess whether the operation is profitable or not by applying some parameters or performance indicators, which are explained below.

The economic studies of profitability and viability must compare future scenarios (not only in the present) to be able to consistently value their profitability.

Most of these parameters are necessary to perform an exhaustive and correct economic calculation. The problem is that some of them are difficult to predict in the future time due to the fluctuations they have. The two most difficult to quantify due to this variable component are:

- The behavior of the users of the building, since the energy consumption depends to a great extent on the use made of the houses. Only the consumption bills allow to know in a realistic way the energy expenditure. If a computer program is used for this calculation, estimates will only be obtained that try to anticipate future results but that never correspond faithfully to reality. Obviously, the better the model is, the closer it will be to real results.

- Evolution of the price of fuels. In long-term scenarios, it is impossible to know what the evolution of fuel prices will be. They depend on many factors: politicians, commercial strategies, availability of natural resources... that can change the usual trend of these prices. The economic calculation models try to approach this future evolution, but it will always be an estimate.

The difficulty in obtaining these parameters is the main reason that classifies the economic performance indicators of the investment in two large groups:

Indicators of profitability in the present time

Indicators of future time profitability

Indicadores de rentabilidad en tiempo presente

They do not take into account estimates of variables that may change in the future such as inflation, increase in maintenance costs, interest rates, fluctuations in fuel prices...

This group includes the gross amortization period, the gross return on investment or the benefit / cost ratio.

They are the easiest to calculate and allow a very simple approximation to the results, but sensitive information is lost regarding the possible fluctuations of certain variables in the future.

Indicators of future time profitability

They make long-term estimates taking into account parameters that are not yet known: inflation and interest rates, maintenance costs increase, fuel price fluctuations...

The most used are the NPV (Net Present Value) and the IRR (Internal Rate of Return). That is why they usually analyze at least two scenarios, one pessimistic and one optimistic, to somehow establish the range of possibilities that can occur.

2. Pay back simple

The **Gross Amortization Period** is also known as a **simple pay-back** or **return on investment time**.

This parameter allows to establish if an investment can be recovered in a reasonable time compared to the estimated life of the equipment.

Although there is no minimum value from which the investment is considered profitable, it is obvious that the lower the gross amortization period, the earlier the investment will be recovered and the more profitable the operation will be. As a recommendation, it can be said that if the period is less than half of the estimated useful life of the investment, investment is usually considered profitable.

It is normally used when you only want to take into account the "cash-flow", that is, the main motivation is to recover the investment as soon as possible with the generated profit.

It is the fastest and most used value in the vast majority of simple economic studies because it allows you to obtain a time value of the investment's amortization in a very simple way. Even so, if the amortization occurs in several years, the precision can be seen greatly altered by the variables that are not used in its calculation, such as the price of fuels, the inflation rate, the increase in the costs of maintenance…

The gross payback period is calculated as the quotient resulting from dividing the total cost of the initial investment by the net annual savings of the implemented measure.

$$\boxed{PB = \frac{Inversión}{AhorroAnualNeto}}$$

PB: Pay-back or total amortization period (in years)

I: Initial investment of the measure including costs in equipment, auxiliary means and labor (€)

A: Net annual saving: It is the difference between the savings due to the reduction of the energy consumption and the annual maintenance and operation cost (€ / year)

Example: Calculation of the gross amortization period

The replacement of electromagnetic ballasts in two luminaires with electronic ballasts is proposed as a measure of energy saving.

The current and future consumption data are the following:

Consumo eléctrico anual actual (KWh/año)	**1228,50**	
Consumo eléctrico anual futuro (KWh/año)	**859,95**	
Ahorro energético anual neto (Kwh/año)	**368,55**	
Precio del combustible (€/Kwh)	**0,17**	
Ahorro anual neto (€/año)	62,65	A
Inversión total (equipos, mano obra...) (€)	240,00	I
Periodo de amortización bruta (años)	3,83	PB

The measure is amortized in 3.83 years. Taking into account a useful life of about 25 years, it is clear that it seems a very profitable measure.

Example: Calculation of the gross amortization period

The installation of exterior solar protection sheets on the glazed surfaces of the corridors facing south and west is proposed.

The current and future consumption data are the following:

Consumo refrigeación electricidad anual actual (KWh/año)	**14390,00**	
Consumo refrigeación electricidad anual futuro (KWh/año)	**10073,00**	
Ahorro energético anual neto (Kwh/año)	**4317,00**	
Precio del combustible (€/Kwh)	**0,17**	
Ahorro anual neto (€/año)	733,89 €	A
Vida útil de la medida (años)	15	VU
Ahorro total neto (A·VU)	11.008,35 €	AN
Inversión total (equipos, mano obra...) (€)	3.090,00 €	I
Periodo de amortización bruta (años)	4,21	PB

The measure is amortized in 4.21 years. Taking into account a useful life of about 15 years, the measure seems very profitable.

3. Gross return on investment

The Gross Return on Investment (RGB) is defined as the percentage ratio of the benefit obtained throughout the life of the equipment with respect to the initial investment.

Although it is calculated with the parameter of the useful life of the measure to be applied, it is another of the present-time indicators because it does not take into account the oscillations of certain variables in the future (price increase, interest rates ...)

It is calculated by means of the following expression:

$$\boxed{RGB = \frac{AhorroTotalNeto - Inversión}{Inversión}}$$

$$\boxed{AhorroTotalNeto = AhorroAnualNeto \times VidaÚtil}$$

RGB: Gross return on investment (in %).

AN: Total net saving of the investment (€). It is calculated as the product of the net annual savings multiplied by the useful life of the measure.

A: Net annual savings: It is the difference between the savings due to the reduction of energy consumption and the annual cost of maintenance and operation (€ / year).

VU: Useful life of the measurement in years.

I: Initial investment of the measure including costs in equipment, auxiliary means and labor (€)

If the value is positive (> 0%), the investment would be profitable if the life expectancy is met. The higher the gross return of the investment in%, the better the investment.

Example: Calculation of gross return on investment

The replacement of electromagnetic ballasts in two luminaires with electronic ballasts is proposed as a measure of energy saving.

The current and future consumption data are the following:

Consumo eléctrico anual actual (KWh/año)	**1228,50**	
Consumo eléctrico anual futuro (KWh/año)	**859,95**	
Ahorro energético anual neto (Kwh/año)	**368,55**	
Precio del combustible (€/Kwh)	**0,17**	
Ahorro anual neto (€/año)	62,65 €	A
Vida útil de la medida (años)	25	VU
Ahorro total neto (AN·VU)	1.566,34 €	AN
Inversión total (equipos, mano obra...) (€)	240,00 €	I
Rendimiento bruto de la inversión (%)	553%	RGB

In this case, as it is a measure of low investment cost and high useful life, the performance is very important. You get a 553% savings on the initial investment.

Example: Calculation of gross return on investment

The installation of exterior solar protection sheets on the glazed surfaces of the south and west facing corridors is proposed.

The current and future consumption data are the following:

Consumo refrigeración electricidad anual actual (KWh/año)	**14390,00**	
Consumo refrigeración electricidad anual futuro (KWh/año)	**10073,00**	
Ahorro energético anual neto (Kwh/año)	**4317,00**	
Precio del combustible (€/Kwh)	**0,17**	
Ahorro anual neto (€/año)	733,89 €	A
Vida útil de la medida (años)	15	VU
Ahorro total neto (A·VU)	11.008,35 €	AN
Inversión total (equipos, mano obra...) (€)	3.090,00 €	I
Periodo de amortización bruta (años)	4,21	PB
Rendimiento bruto de la inversión (%)	256%	RGB

In this case, as it is a measure of low investment cost and high useful life, the performance is very important. You get a 256% savings on the initial investment.

4. Annual gross yield

The Annual Gross Return (RBA) is the value of the gross return on investment (RGB) divided by the useful life of the measure. It is, therefore, the% annual return on investment.

$$\boxed{RBA = \frac{RGB}{VidaÚtil}}$$

RBA: Annual gross yield (in%).

RGB: Gross return on investment (in%).

VU: Useful life of the measurement in years.

As in the case of the Gross Return on Investment (RGB), if the value is positive (> 0%), the investment would be profitable if the life expectancy is met. The higher the gross return of the investment in%, the better the investment.

Example: Calculation of the annual gross return on investment

The replacement of electromagnetic ballasts in two luminaires with electronic ballasts is proposed as a measure of energy saving.

The current and future consumption data are the following:

Consumo eléctrico anual actual (KWh/año)	**1228,50**	
Consumo eléctrico anual futuro (KWh/año)	**859,95**	
Ahorro energético anual neto (Kwh/año)	**368,55**	
Precio del combustible (€/Kwh)	**0,17**	
Ahorro anual neto (€/año)	62,65 €	A
Vida útil de la medida (años)	25	VU
Ahorro total neto (AN·VU)	1.566,34 €	AN
Inversión total (equipos, mano obra...) (€)	240,00 €	I
Rendimiento bruto de la inversión (%)	553%	RGB
Rendimiento bruto anual de la inversión (%) (RGB/VU)	22%	RBA

You get a 22% annual savings on the initial investment. It is a large number given the characteristics of it.

Example: Calculation of the annual gross return on investment

The installation of exterior solar protection sheets on the glazed surfaces of the south and west facing corridors is proposed.

The current and future consumption data are the following:

Consumo refrigeración electricidad anual actual (KWh/año)	**14390,00**	
Consumo refrigeración electricidad anual futuro (KWh/año)	**10073,00**	
Ahorro energético anual neto (Kwh/año)	**4317,00**	
Precio del combustible (€/Kwh)	**0,17**	
Ahorro anual neto (€/año)	733,89 €	A
Vida útil de la medida (años)	15	VU
Ahorro total neto (A·VU)	11.008,35 €	AN
Inversión total (equipos, mano obra...) (€)	3.090,00 €	I
Periodo de amortización bruta (años)	4,21	PB
Rendimiento bruto de la inversión (%)	256%	RGB
Rendimiento bruto anual de la inversión (%) (RGB/VU)	17%	RBA

You get a 17% annual savings on the initial investment. It is a large number given the characteristics of it.

5. Return on Investment Rate (TRI)

The **Return on Investment Rate** (TRI) takes into account the estimated life of the equipment in terms of its depreciation.

It is calculated in the period of useful life that is wanted, that is to say, different simulations by year can be done that allow to know the yield of the investment in each concrete year. In the study year equivalent to the useful life of the saving measure, the TRI is equivalent to the Gross Return on Investment (RGB). As in the RGB, the higher the%, the better the investment. To justify the investment, it is necessary that the TRI corresponding to the installation analyzed is greater than that corresponding to other investment alternatives.

$$\boxed{TRI = \frac{AhorroTotalNetoAñoEstudio - DepreciaciónAnual * AñoEstudio}{Inversión}}$$

$$\boxed{DepreciaciónAnual = \frac{Inversión}{VidaÚtil}}$$

TRI: Rate of return on investment (in%).

ANE: Total net saving of the investment (€). It is calculated as the product of the net annual savings multiplied by the useful life of the measure:

A: Net annual saving: It is the difference between the savings due to the reduction of the energy consumption and the annual maintenance and operation cost (€ / year)

AE: Years of study since the measure was implemented

D: Annual depreciation. It is calculated as the quotient between the initial investment (I) and the useful life of the measure if a linear depreciation is considered.

I: Initial investment of the measure including costs in equipment, auxiliary means and labor (€)

VU: Useful life of the measurement in years.

AE: Years of study since the measure was implemented.

Example: Calculation of the rate of return on investment (TRI)

The replacement of electromagnetic ballasts in two luminaires with electronic ballasts is proposed as a measure of energy saving.

The current and future consumption data are the following:

Consumo eléctrico anual actual (KWh/año)	**1228,50**	
Consumo eléctrico anual futuro (KWh/año)	**859,95**	
Ahorro energético anual neto (Kwh/año)	**368,55**	
Precio del combustible (€/Kwh)	**0,17**	
Ahorro anual neto (€/año)	62,65 €	A
Vida útil de la medida (años)	25	VU
Inversión total (equipos, mano obra...) (€)	240,00 €	I
Depreciación anual de la inversión (€)	9,60 €	D
Año de estudio	5	AE
Ahorro total neto año de estudio (A·AE)	313	ANE
Tasa de retorno de la inversión (TRI) (%)	111%	TRI

Calculation of the rate of return on investment of a measure of energy saving in year 5 with a useful life of 25 years

Consumo eléctrico anual actual (KWh/año)	**1228,50**	
Consumo eléctrico anual futuro (KWh/año)	**859,95**	
Ahorro energético anual neto (Kwh/año)	**368,55**	
Precio del combustible (€/Kwh)	**0,17**	
Ahorro anual neto (€/año)	62,65 €	A
Vida útil de la medida (años)	25	VU
Inversión total (equipos, mano obra...) (€)	240,00 €	I
Depreciación anual de la inversión (€)	9,60 €	D
Año de estudio	15	AE
Ahorro total neto año de estudio (A·AE)	940	ANE
Tasa de retorno de la inversión (TRI) (%)	332%	TRI

Calculation of the rate of return on investment of a measure of energy savings in year 15 with a useful life of 25 years

Consumo eléctrico anual actual (KWh/año)	**1228,50**	
Consumo eléctrico anual futuro (KWh/año)	**859,95**	
Ahorro energético anual neto (Kwh/año)	**368,55**	
Precio del combustible (€/Kwh)	**0,17**	
Ahorro anual neto (€/año)	62,65 €	A
Vida útil de la medida (años)	25	VU
Inversión total (equipos, mano obra...) (€)	240,00 €	I
Depreciación anual de la inversión (€)	9,60 €	D
Año de estudio	25	AE
Ahorro total neto año de estudio (A·AE)	1566	ANE
Tasa de retorno de la inversión (TRI) (%)	553%	TRI

Calculation of the rate of return on investment of an energy saving measure in year 25 with a useful life of 25 years

You get 553% as the rate of return on investment. As calculated at the end of the useful life, it coincides with the gross return on investment (RGB) since the depreciation of the measure has been completed.

Example: Calculation of the rate of return on investment (TRI)

The installation of exterior solar protection sheets on the glazed surfaces of the south and west facing corridors is proposed.

The current and future consumption data are the following:

Consumo refrigeración electricidad anual actual (KWh/año)	**14390,00**	
Consumo refrigeración electricidad anual futuro (KWh/año)	**10073,00**	
Ahorro energético anual neto (Kwh/año)	**4317,00**	
Precio del combustible (€/Kwh)	**0,17**	
Ahorro anual neto (€/año)	733,89 €	A
Vida útil de la medida (años)	15	VU
Depreciación anual de la inversión (€)	206,00 €	D
Año de estudio	5	AE
Ahorro total neto año de estudio (A·AE)	3669	ANE
Tasa de retorno de la inversión (TRI) (%)	85%	TRI

Cálculo de la tasa de retorno de la inversión de una medida de ahorro energético en el año 5 con una vida útil de 15 años

Consumo refrigeración electricidad anual actual (KWh/año)	**14390,00**	
Consumo refrigeración electricidad anual futuro (KWh/año)	**10073,00**	
Ahorro energético anual neto (Kwh/año)	**4317,00**	
Precio del combustible (€/Kwh)	**0,17**	
Ahorro anual neto (€/año)	733,89 €	A
Vida útil de la medida (años)	15	VU
Depreciación anual de la inversión (€)	206,00 €	D
Año de estudio	10	AE
Ahorro total neto año de estudio (A·AE)	7339	ANE
Tasa de retorno de la inversión (TRI) (%)	171%	TRI

Calculation of the rate of return on investment of an energy saving measure in year 10 with a useful life of 15 years

Consumo refrigeración electricidad anual actual (KWh/año)	**14390,00**	
Consumo refrigeración electricidad anual futuro (KWh/año)	**10073,00**	
Ahorro energético anual neto (Kwh/año)	**4317,00**	
Precio del combustible (€/Kwh)	**0,17**	
Ahorro anual neto (€/año)	733,89 €	A
Vida útil de la medida (años)	15	VU
Depreciación anual de la inversión (€)	206,00 €	D
Año de estudio	15	AE
Ahorro total neto año de estudio (A·AE)	11008	ANE
Tasa de retorno de la inversión (TRI) (%)	256%	TRI

Calculation of the rate of return on investment of a measure of energy saving in year 15 with a useful life of 15 years

256% is obtained as a return on investment. As calculated at the end of the useful life, it coincides with the gross return on investment (RGB) since the depreciation of the measure has been completed.

6. Benefit / Cost Ratio (B/C)

The criterion of the Benefit-Cost Ratio is to calculate the relationship between the present value of the benefits and the present value of the costs, using the discount rate for its calculation.

The Benefit - Cost ratio (B / C) is the quotient between the absolute value of costs and benefits, updated at present value. It is therefore the first of the indicators that work with future variables that must be updated to the present, in this case, it is the discount rate.

Unlike the previous parameters, this indicator takes into account the evolution of the benefits in each of the years as well as the costs.

The internal rate of return that you want to obtain or discount rate is the% of minimum return required to an investment, either because the capital is borrowed and the cost of bank interest must be assumed, or because you could have decided to invest in another product that generates more profitability (this is what is called opportunity cost).

A normal value could be set by the% of interest that the bank provides for a fixed-term deposit or for the value of Treasury Bills. That is, for the performance of a safe investment in the medium or long term.

For higher risk private investments, the discount rate could be set at 10%.

The discount rate could be defined as the opportunity cost of the investor or effective profitability of the best speculative alternative of equal risk.

In the Benefit - Cost ratio (B / C) both (the costs and benefits) are updated with the same discount rate. The result of the ratio B / C must be greater than 1. The higher it is, the better the investment will be.

At this point the explanation of simple interest and compound interest is necessary to be able to update the future values of yields obtained at a present value.

Simple interest: *It is a form of calculation of interest, where what generates interest during a unit of time (day, week, month, quarter, year, etc ...) is always the original value.*

How is the future value (VF) of a placement of a present value (PV) calculated in n units of time?

At time 1, that is, a period after placing a PV amount, the initial interest plus the period interest will be obtained.

$$I_{0,1} = VP \times i$$

where

I am the interest,

i is the effective interest rate

VP is the initial placement (present value)

Thus, the future value of period 1 (VF1) is arrived at as:

$$VF_1 = VP + I_{0,1} = VP + VP \times i = VP\ (1+i)$$

At time 2, the interest will be calculated in the same way as for period 1.

So: $I_{1,2} = VP \times i$

Therefore, the future value of the initial placement to period 2 (VF2) is:

$$VF_2 = VF_1 + VP \times i = VP\,(1+i) + VP \times i = VP\,(1+2i)$$

Generalizing, interest for period n-1, n will be

$$I_{n-1,n} = VP \times i$$

In this way, in the last unit of time we will have a future value (VF_n):

$$VF_n = VP\,(1+ni)$$

An important fact in the previous formula is that always n and i have to be expressed in the same unit of time.

That is, if the placement is monthly, the interest rate must be the monthly effective, the same amount is valid if it is quarterly, annual, etc.

Compound interest: *What generates interest during a unit of time is the value of the placement at the beginning of the unit of time that is being analyzed.*

What is the future value generated by a certain present value placed at an effective interest rate i of compound interest defined in a certain unit of time during n periods?

Proceeding as in the case of simple interest, the first period we have:

$$I_{0,1} = VP \times i$$

where:

I is the interest

i is the effective interest rate

VP is the initial placement (present value)

Then the future value at time 1 (VF1) will be:

$$VF_1 = VP + I_{0,1} = VP + VP \times i = VP\,(1+i)$$

In period 2, what generates interest is the value at the beginning of the period, that is, the VF1.

Thus: $I_{1,2} = VF_1 \times i = VP\,(1+i) \times i$

With this, the future value to period two will be:

$$VF_2 = VF_1 + I_{1,2} = VP\,(1+i) + VP\,(1+i) \times i = VP\,(1+i)^2$$

Generalizing for the moment n it is obtained that:

$$VF_n = VF_{n-1} + I_{n-1,n} = VP\,(1+i)^{n-1} + VP\,(1+i)^{n-1} \times i = VP\,(1+i)^n$$

$$VF_n = VP\,(1+i)^n$$

The substantial difference with the simple interest case is that, in this case, the interests that are being generated become part of that mass that generates interest: this process is known as capitalization of interest.

Example of simple interest calculation

€ 5,000 is placed at 2 years, at an annual effective interest rate of 23%. What will be the future value of the placement at the end of it?

$$VF = VP\ (1+ni) = 5.000\ (1+2\cdot 0.23) = 7.300$$

In other words, after two years a value of € 7,300 will be obtained, with the placement of € 5,000.

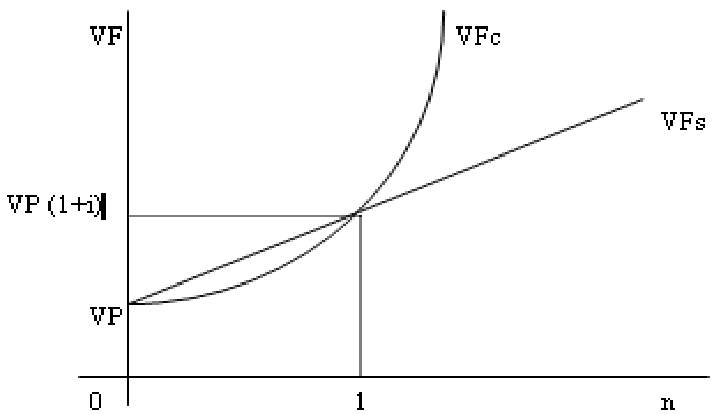
Example of compound interest calculation

If the previous example is maintained, where € 5,000 is placed at 2 years, at an annual effective interest rate of 23%. What will be the future value of the placement at the end of it?

$$VF = VP\ (1+i)^2 = 5.000\ (1+ 0,23)^2 = 7.564,5$$

In other words, after two years a value of € 7,564.5 will be obtained with the placement of € 5,000.

In the previous example, it can be observed that the future value achieved at compound interest is higher than that obtained at simple interest.



Simple and compound interest evolution graphs

Returning to the B / C ratio, and being the relationship between the present value of the benefits and the present value of the costs using the discount rate for its calculation, it will be necessary to adapt the future values of benefits and costs to the present.

Example: Calculation of the B / C ratio

It is based on an investment that predicts the following benefits and costs over the next 4 years.

	Año 0	Año 1	Año 2	Año 3	Año 4
Beneficios		5.000,00 €	4.000,00 €	2.500,00 €	2.500,00 €
Costes	10.000,00 €	300,00 €	150,00 €	150,00 €	150,00 €

If a discount rate of 14% is assumed, then there would be an evolution

of updated values of benefits and costs (VAB and VAC)

$$VAB = \frac{5{,}000}{(1+0.14)^1} + \frac{4{,}000}{(1+0.14)^2} + \frac{2{,}500}{(1+0.14)^3} + \frac{2{,}000}{(1+0.14)^4} = 10{,}703.55$$

$$VAC = -(-\frac{10{,}000}{(1+0.14)^0} - \frac{300}{(1+0.14)^1} - \frac{150}{(1+0.14)^2} - \frac{150}{(1+0.14)^3} - \frac{150}{(1+0.14)^4}) = 10{,}589$$

Resulting in a B / C ratio of:

$$B/C = 1.01$$

At the moment when the B / C ratio becomes greater than 1, this implies that the investment becomes profitable. In this example, year 4 is the year in which the investment is profitable.

7. Investment update (NPV)

It is the current value of the net benefits generated by the project. The rate at which the flows are discounted represents the opportunity cost of capital (discount rate).

The NPV measures, in today's currency, how much richer the investor will be if he / she carries out the project, instead of placing his / her money in the activity that the Discount Rate offers as a return.

The NPV serves to generate two types of decisions: first, to see if the investments are profitable and, second, to see which investment is better than another in absolute terms.

The decision criteria will be the following:

- NPV> 0, the updated value of the future payments and payments of the investment, at the chosen discount rate will generate benefits.

- NPV = 0, the investment project will not generate profits or losses, being its realization, in principle, indifferent.

- NPV <0, the investment project will generate losses, so it must be rejected.

The NPV is the first of the indicators that allows, when performing an annual calculation, to use variables that may evolve in the future such as inflation in maintenance costs, the price of fuels, interest rate in case of loans...

As its name indicates, the NPV updates to present the cash flows (income - expenses) of each year during the useful life of an investment.

The Cash Flow synthesizes the cash movements that will take place during the life of the project, both in the execution stage and in the operation stage. Cash flow is constructed for the entire life of the project, also known as the "evaluation horizon".

The calculation of the NPV is complex and, although it can be represented by the following formula, the best way to explain your method is through a simple example, which will be detailed later.

$$VAN = -I_0 + \sum_{t=1}^{n} \frac{F_t}{(1+k)^t} = -I_0 + \frac{F_1}{(1+k)} + \frac{F_2}{(1+k)^2} + \cdots + \frac{F_n}{(1+k)^n}$$

F_t son los flujos de dinero en cada periodo t

I_0 es la inversión realiza en el momento inicial (t = 0)

n es el número de periodos de tiempo

k es el tipo de descuento o tipo de interés exigido a la inversión

The NPV has several advantages when it comes to evaluating investment projects: the main advantage is that it is an easy method to calculate and in turn provides useful predictions about the effects of investment projects on the value of the company. In addition, it takes into account the different maturities of the net cash flows.

But, in spite of its advantages, it also has some drawbacks such as the difficulty of specifying a discount rate. That is, we work under the hypothesis of reinvestment of net cash flows, since it is implicitly assumed that positive net cash flows are reinvested immediately at a rate that coincides with the discount rate, and that net cash flows Negatives are financed with resources whose cost is also the discount rate.

EXAMPLE OF THE NPV CALCULATION

For an energy saving measure, an investment of 500,000 euros is programmed. The calculations promise us that after that investment the first year 600,000 € will be generated and 250,000 will be spent, while for the second year 700,000 € will be generated and 300,000 € will be spent. It is requested to calculate the NPV at two years.

	Año 0, t=0	Año 1, t=1	Año 2, t=2
Inversión	500.000,00 €		
Beneficios		600.000,00 €	700.000,00 €
Costes		250.000,00 €	300.000,00 €

The first step to calculate the NPV is to know the cash flow (Income - Expenses) of each of the years that you want to perform the calculation.

	Año 0, t=0	Año 1, t=1	Año 2, t=2
Inversión	500.000,00 €		
Beneficios		600.000,00 €	700.000,00 €
Costes		250.000,00 €	300.000,00 €
Flujo de caja (Ft)	**- 500.000,00 €**	**350.000,00 €**	**400.000,00 €**
	F_0	F_1	F_2

If we assume a discount rate of 10% (k = 0.1), the calculation formula of the NPV would be as follows:

	Año 0, t=0	Año 1, t=1	Año 2, t=2
Inversión	500.000,00 €		
Beneficios		600.000,00 €	700.000,00 €
Costes		250.000,00 €	300.000,00 €
Flujo de caja (Ft)	**- 500.000,00 €**	**350.000,00 €**	**400.000,00 €**
	F_0	F_1	F_2
Tasa de descuento (k)	10%	10%	10%
$(1 + k)^t$	1,00	1,10	1,21
$F_t / (1 + k)^t$	**- 500.000,00 €**	**318.181,82 €**	**330.578,51 €**
VAN =	**148.760,33 €**		

By virtue of the result obtained, the project proposes a net benefit valued at time 0 that exceeds the investment of € 148,760.33, which is convenient to carry out.

In summary, the basis of the NPV is that, year after year, the reduction of costs amortizes the investment made, until it is recovered together with the expected interest.

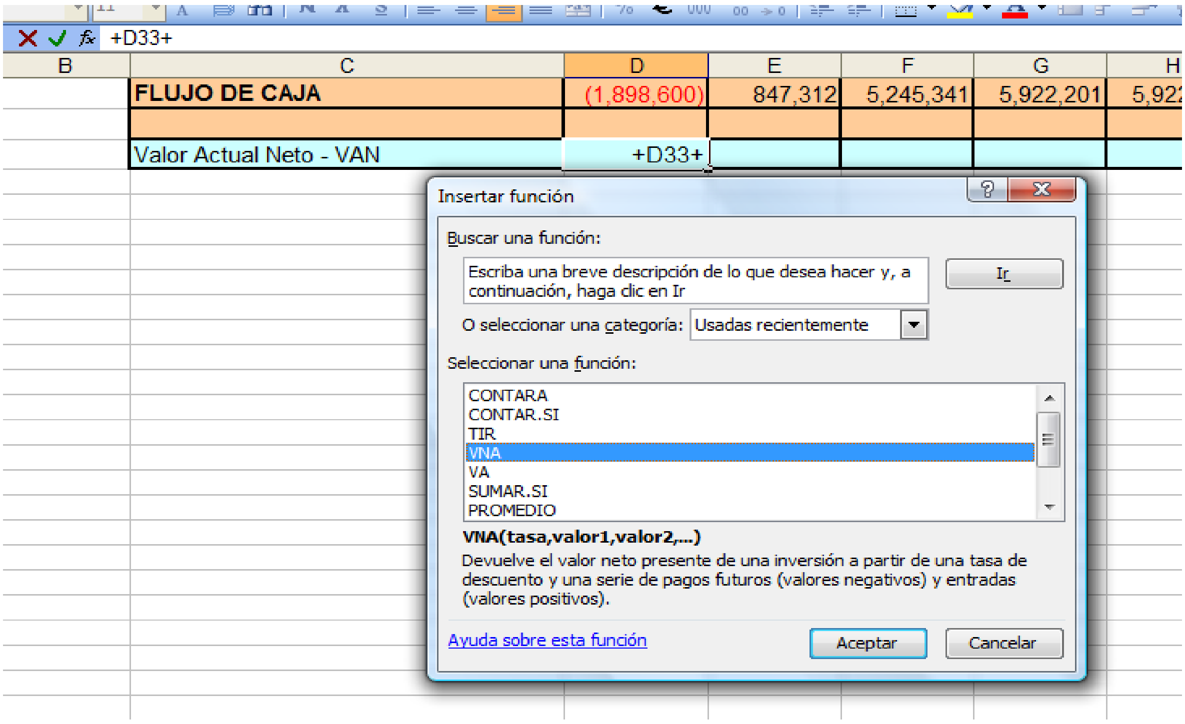
It seems logical to think that, if the reduction of the NPV is always progressive, the investment always recovers, it is only a matter of time (years) that the value of the NPV becomes positive.

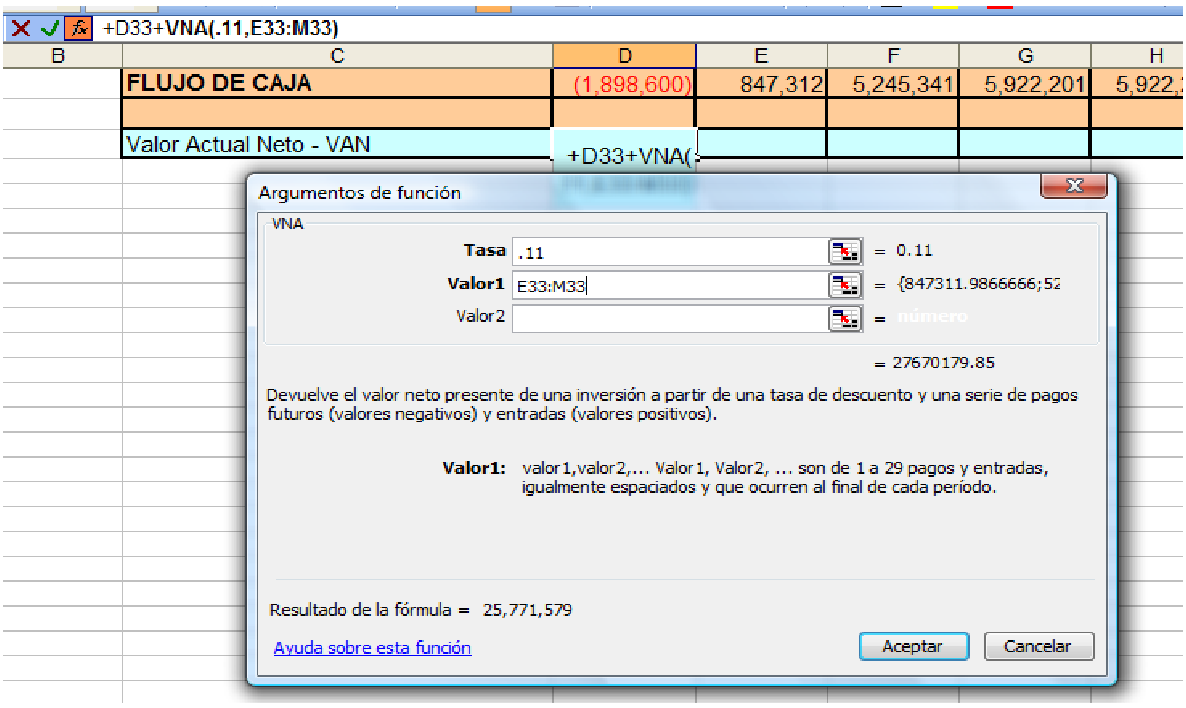
But energy efficiency measures do not have an infinite useful life. It will therefore be necessary to assess what is the reasonable life cycle of the energy efficiency measures that are proposed, understood as the period of time that passes until they must be replaced or important reforms are carried out.

In the case of passive measures (insulation, windows, solar protection, etc.), it is considered to be around 30 years, while in active measures it is reduced to 15 years, as periods in which the equipment is usually They must be replaced.

On the other hand, the investor can put constraints on his investment, such as shorter return periods or higher discount rates, since the uncertainty and with it the risk of the investment increases with time.

The NPV can also be calculated quickly by using functions in EXCEL.


+D33+
B
C
D
E
F
G
H
FLUJO DE CAJA
(1,898,600)
847,312
5,245,341
5,922,201
Valor Actual Neto - VAN
+D33+
Insertar función
Buscar una función:
Escriba una breve descripción de lo que desea hacer y, a continuación, haga clic en Ir
Ir
O seleccionar una categoría: Usadas recientemente
Seleccionar una función:
CONTARA
CONTAR.SI
TIR
VNA
VA
SUMAR.SI
PROMEDIO
VNA(tasa,valor1,valor2,...)
Devuelve el valor neto presente de una inversión a partir de una tasa de descuento y una serie de pagos futuros (valores negativos) y entradas (valores positivos).
Ayuda sobre esta función
Aceptar
Cancelar


+D33+VNA(.11,E33:M33)
B
C
D
E
F
G
H
FLUJO DE CAJA
(1,898,600)
847,312
5,245,341
5,922,201
Valor Actual Neto - VAN
+D33+VNA(
Argumentos de función
VNA
Tasa .11 = 0.11
Valor1 E33:M33 = {847311.9866666;52
Valor2 =
= 27670179.85
Devuelve el valor neto presente de una inversión a partir de una tasa de descuento y una serie de pagos futuros (valores negativos) y entradas (valores positivos).
Valor1: valor1,valor2,... Valor1, Valor2, ... son de 1 a 29 pagos y entradas, igualmente espaciados y que ocurren al final de cada período.
Resultado de la fórmula = 25,771,579
Ayuda sobre esta función
Aceptar
Cancelar

B	C	D	E	F	G	H
	FLUJO DE CAJA	(1,898,600)	847,312	5,245,341	5,922,201	5,922,201
	Valor Actual Neto - VAN	25,771,579				

8. Internal rate of return (TIR)

The Internal Rate of Return (IRR) is the interest rate or return offered by an investment. That is, it is the percentage of profit or loss that an investment will have for the amounts that have not been withdrawn from the project. Measures the average annual return generated by the capital that remains invested in the project.

It is a measure used in the evaluation of investment projects that is closely related to the Net Updated Value (NPV). It is also defined as the value of the discount rate that makes the NPV equal to zero, for a given investment project.

The internal rate of return (IRR) gives us a relative measure of profitability, that is, it will be expressed as a percentage. The main problem lies in its calculation, since the number of periods will give the order of the equation to solve. To solve this problem you can go to different approaches, use a financial calculator or a computer program.

The project will be profitable if the IRR is greater than the discount rate: the yield obtained is greater than the profitability of the best speculative alternative of equal risk.

The IRR does not take into account the money that is withdrawn from the business each period as a result of profits, but only the money that remains invested in the project.

The IRR is the value of the parameter k for which the NPV of the flows generated by the project during its useful life equals the value of the initial investment made (I).

It is calculated by the following expression:

$$VAN = -I_0 + \sum_{t=1}^{n} \frac{F_t}{(1+TIR)^t} = -I_0 + \frac{F_1}{(1+TIR)} + \frac{F_2}{(1+TIR)^2} + \cdots + \frac{F_n}{(1+TIR)^n} = 0$$

F_t son los flujos de dinero en cada periodo t

I_0 es la inversión realiza en el momento inicial (t = 0)

n es el número de periodos de tiempo

The decision criteria will be the following:

- IRR> Desired discount rate: The profitability of the project is higher than the acceptable minimum. The project should be accepted.
- IRR = Desired discount rate. The profitability of the project is equal to the interest it would receive when investing said capital in the best alternative. The project is indifferent.
- IRR <Desired discount rate. The profitability of the project is lower than the best alternative option. The project should be rejected.

EXAMPLE OF THE CALCULATION OF THE IRR

For an energy saving measure, an investment of 500,000 euros is programmed. The calculations and they promise us that after that investment the first year will generate 600,000 € s and 250,000 will be spent, while for the second year 700,000 € will be generated and 300,000 € will be spent. It is requested to calculate the IRR.

	Año 0, t=0	Año 1, t=1	Año 2, t=2
Inversión	500.000,00 €		
Beneficios		600.000,00 €	700.000,00 €
Costes		250.000,00 €	300.000,00 €

The first step is to calculate the NPV for what you need to know the cash flow (Income - Expenses) of each of the years you want to perform the calculation.

	Año 0, t=0	Año 1, t=1	Año 2, t=2
Inversión	500.000,00 €		
Beneficios		600.000,00 €	700.000,00 €
Costes		250.000,00 €	300.000,00 €
Flujo de caja (Ft)	**- 500.000,00 €**	**350.000,00 €**	**400.000,00 €**
	F_0	F_1	F_2

So far the process is the same as in the calculation of the NPV. The IRR is the value of k (in the NPV formula) that allows the NPV equation of a value of 0.

Its calculation is complicated and although it can be done through simulation programs the simplest way is through several manual checks.

We make, for example, the first simulation with a value of k = 0.05 (5%). Is obtained:

	Año 0, t=0	Año 1, t=1	Año 2, t=2
Inversión	500.000,00 €		
Beneficios		600.000,00 €	700.000,00 €
Costes		250.000,00 €	300.000,00 €
Flujo de caja (Ft)	**- 500.000,00 €**	**350.000,00 €**	**400.000,00 €**
	F_0	F_1	F_2
Tasa de descuento (k)	5%	5%	5%
$(1 + k)^t$	1,00	1,05	1,10
$F_t / (1 + k)^t$	- 500.000,00 €	333.333,33 €	362.811,79 €
VAN =	**196.145,12 €**		

The value of the NPV for k = 0.05 (5%) is positive so that we continue testing, for example, with k = 0.1 (10%). Is obtained:

	Año 0, t=0	Año 1, t=1	Año 2, t=2
Inversión	500.000,00 €		
Beneficios		600.000,00 €	700.000,00 €
Costes		250.000,00 €	300.000,00 €
Flujo de caja (Ft)	**- 500.000,00 €**	**350.000,00 €**	**400.000,00 €**
	F_0	**F_1**	**F_2**
Tasa de descuento (k)	10%	10%	10%
$(1 + k)^t$	1,00	1,10	1,21
$F_t / (1 + k)^t$	**- 500.000,00 €**	**318.181,82 €**	**330.578,51 €**
VAN =	**148.760,33 €**		

The value of the NPV for k = 0.10 (10%) is positive so that we continue testing, for example, with k = 0.2 (20%). Is obtained:

	Año 0, t=0	Año 1, t=1	Año 2, t=2
Inversión	500.000,00 €		
Beneficios		600.000,00 €	700.000,00 €
Costes		250.000,00 €	300.000,00 €
Flujo de caja (Ft)	**- 500.000,00 €**	**350.000,00 €**	**400.000,00 €**
	F_0	**F_1**	**F_2**
Tasa de descuento (k)	20%	20%	20%
$(1 + k)^t$	1,00	1,20	1,44
$F_t / (1 + k)^t$	**- 500.000,00 €**	**291.666,67 €**	**277.777,78 €**
VAN =	**69.444,44 €**		

The value of the NPV for k = 0.20 (20%) remains positive even though it is reduced so that we continue testing, for example, with k = 0.3 (30%). Is obtained:

	Año 0, t=0	Año 1, t=1	Año 2, t=2
Inversión	500.000,00 €		
Beneficios		600.000,00 €	700.000,00 €
Costes		250.000,00 €	300.000,00 €
Flujo de caja (Ft)	**- 500.000,00 €**	**350.000,00 €**	**400.000,00 €**
	F_0	**F_1**	**F_2**
Tasa de descuento (k)	30%	30%	30%
$(1 + k)^t$	1,00	1,30	1,69
$F_t / (1 + k)^t$	**- 500.000,00 €**	**269.230,77 €**	**236.686,39 €**
VAN =	**5.917,16 €**		

The value of the NPV for k = 0.30 (30%) is still positive although it is practically 0 so that we continue testing, for example, with k = 0.32 (32%). Is obtained:

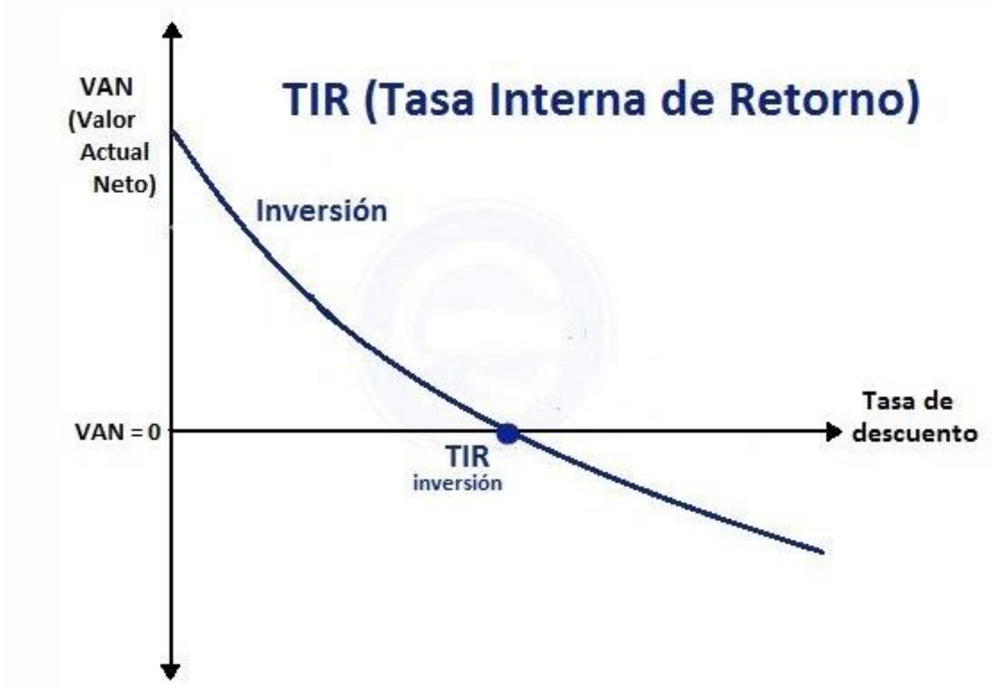
	Año 0, t=0	Año 1, t=1	Año 2, t=2
Inversión	500.000,00 €		
Beneficios		600.000,00 €	700.000,00 €
Costes		250.000,00 €	300.000,00 €
Flujo de caja (Ft)	**- 500.000,00 €**	**350.000,00 €**	**400.000,00 €**
	F_0	**F_1**	**F_2**
Tasa de descuento (k)	32%	32%	32%
$(1 + k)^t$	1,00	1,32	1,74
$F_t / (1 + k)^t$	**- 500.000,00 €**	**265.151,52 €**	**229.568,41 €**
VAN =	**- 5.280,07 €**		

The value of the NPV for k = 0.32 (32%) is now negative, so the calculated rate should be between 30% and 32%. It is tested with k = 0.31 (31%). Is obtained:

	Año 0, t=0	Año 1, t=1	Año 2, t=2
Inversión	500.000,00 €		
Beneficios		600.000,00 €	700.000,00 €
Costes		250.000,00 €	300.000,00 €
Flujo de caja (Ft)	**- 500.000,00 €**	**350.000,00 €**	**400.000,00 €**
	F_0	**F_1**	**F_2**
Tasa de descuento (k)	31%	31%	31%
$(1 + k)^t$	1,00	1,31	1,72
$F_t / (1 + k)^t$	**- 500.000,00 €**	**267.175,57 €**	**233.086,65 €**
VAN =	**262,22 €**		

The value of the NPV for k = 0.31 (31%) is practically 0, so it can be said that the 2-year IRR for this operation is 31%. That value can be compared to the desired discount rate.

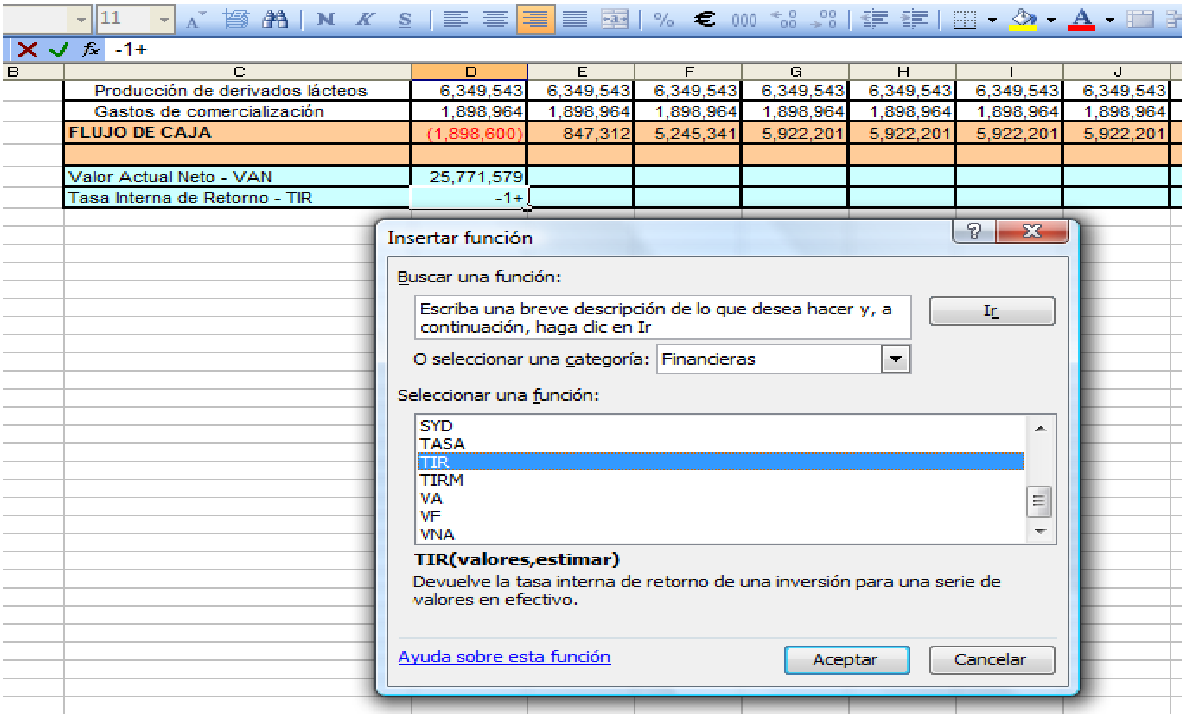
The graphic representation of the NPV and the TIR would give the following results:

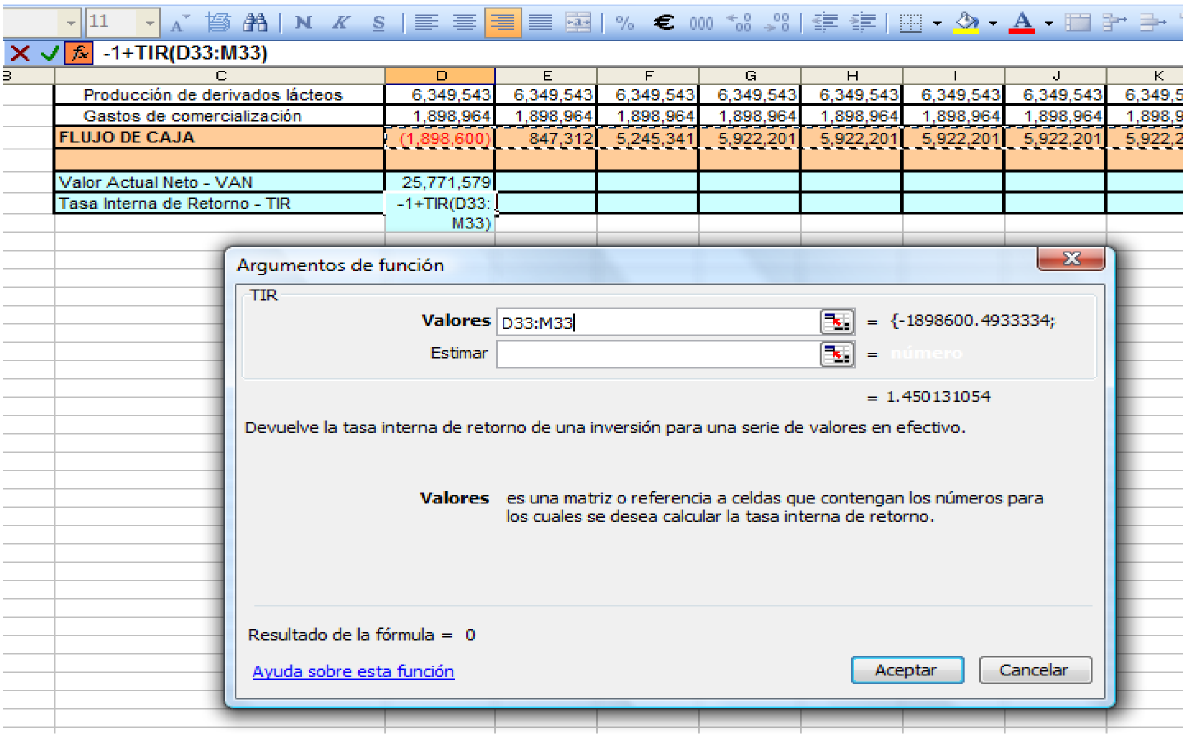


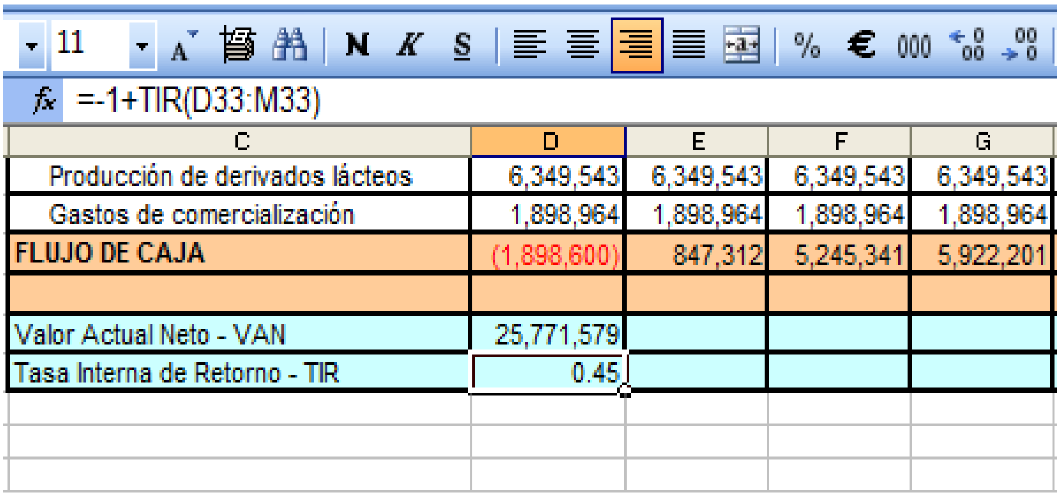
Source: www.economipedia.com

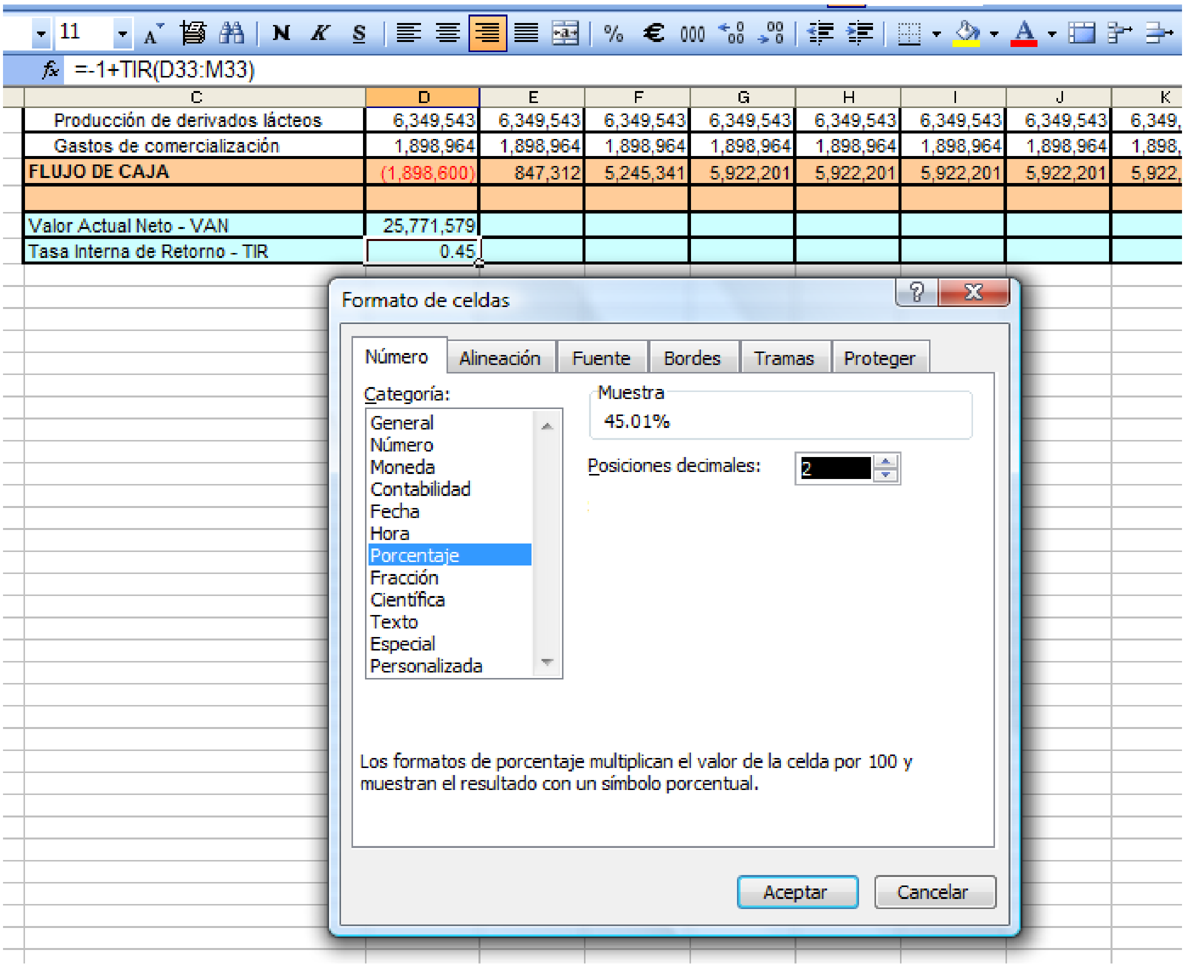
The Internal Rate of Return is the point at which the NPV is zero. So if a NPV of an investment in the Y axis and a discount rate (profitability) in the Y axis are drawn in a graph, the investment will be a downward curve. The IRR will be the point where that investment crosses the abscissa axis, which is the place where the NPV equals zero.

The calculation of the TIR can also be done in a simple way in EXCEL by using functions.


-1+
Producción de derivados lácteos | 6,349,543 | 6,349,543 | 6,349,543 | 6,349,543 | 6,349,543 | 6,349,543 | 6,349,543
Gastos de comercialización | 1,898,964 | 1,898,964 | 1,898,964 | 1,898,964 | 1,898,964 | 1,898,964 | 1,898,964
FLUJO DE CAJA | (1,898,600) | 847,312 | 5,245,341 | 5,922,201 | 5,922,201 | 5,922,201 | 5,922,201
Valor Actual Neto - VAN | 25,771,579
Tasa Interna de Retorno - TIR | -1+
Insertar función
Buscar una función:
Escriba una breve descripción de lo que desea hacer y, a continuación, haga clic en Ir
Ir
O seleccionar una categoría: Financieras
Seleccionar una función:
SYD
TASA
TIR
TIRM
VA
VF
VNA
TIR(valores,estimar)
Devuelve la tasa interna de retorno de una inversión para una serie de valores en efectivo.
Ayuda sobre esta función
Aceptar
Cancelar


-1+TIR(D33:M33)
Producción de derivados lácteos | 6,349,543 | 6,349,543 | 6,349,543 | 6,349,543 | 6,349,543 | 6,349,543 | 6,349,543
Gastos de comercialización | 1,898,964 | 1,898,964 | 1,898,964 | 1,898,964 | 1,898,964 | 1,898,964 | 1,898,964
FLUJO DE CAJA | (1,898,600) | 847,312 | 5,245,341 | 5,922,201 | 5,922,201 | 5,922,201 | 5,922,201
Valor Actual Neto - VAN | 25,771,579
Tasa Interna de Retorno - TIR | -1+TIR(D33:M33)
Argumentos de función
TIR
Valores D33:M33 = {-1898600.4933334;
Estimar = número
= 1.450131054
Devuelve la tasa interna de retorno de una inversión para una serie de valores en efectivo.
Valores es una matriz o referencia a celdas que contengan los números para los cuales se desea calcular la tasa interna de retorno.
Resultado de la fórmula = 0
Ayuda sobre esta función
Aceptar
Cancelar


11
=-1+TIR(D33:M33)
C
D
E
F
G
Producción de derivados lácteos
6,349,543
6,349,543
6,349,543
6,349,543
Gastos de comercialización
1,898,964
1,898,964
1,898,964
1,898,964
FLUJO DE CAJA
(1,898,600)
847,312
5,245,341
5,922,201
Valor Actual Neto - VAN
25,771,579
Tasa Interna de Retorno - TIR
0.45


11
=-1+TIR(D33:M33)
C
D
E
F
G
H
I
J
K
Producción de derivados lácteos
6,349,543
6,349,543
6,349,543
6,349,543
6,349,543
6,349,543
6,349,543
6,349,
Gastos de comercialización
1,898,964
1,898,964
1,898,964
1,898,964
1,898,964
1,898,964
1,898,964
1,898,
FLUJO DE CAJA
(1,898,600)
847,312
5,245,341
5,922,201
5,922,201
5,922,201
5,922,201
5,922,
Valor Actual Neto - VAN
25,771,579
Tasa Interna de Retorno - TIR
0.45
Formato de celdas
Número
Alineación
Fuente
Bordes
Tramas
Proteger
Categoría:
General
Número
Moneda
Contabilidad
Fecha
Hora
Porcentaje
Fracción
Científica
Texto
Especial
Personalizada
Muestra
45.01%
Posiciones decimales:
2
Los formatos de porcentaje multiplican el valor de la celda por 100 y muestran el resultado con un símbolo porcentual.
Aceptar
Cancelar

fx =-1+TIR(D33:M33)

C	D	E	F	G
Producción de derivados lácteos	6,349,543	6,349,543	6,349,543	6,349,543
Gastos de comercialización	1,898,964	1,898,964	1,898,964	1,898,964
FLUJO DE CAJA	(1,898,600)	847,312	5,245,341	5,922,201
Valor Actual Neto - VAN	25,771,579			
Tasa Interna de Retorno - TIR	45.01%			

9. Interpretation of economic parameters: viability and profitability

At this point and known the most used economic indicators, it is necessary to correctly differentiate the terms profitability and viability.

An investment will be considered profitable when it provides income higher than the costs derived from its start-up (in more strict terms, it would be one whose yield is greater than the discount rate or expected opportunity cost).

On the other hand, an investment will be viable when it can really be done.

The terms of profitability and viability are obviously closely related but depend on different factors.

Profitability is a concept that depends, a lot, on the benefits and expenses (as seen in the NPV and TIR), while the treasury account comes into play in viability.

An investment can be profitable in a certain period of time but its execution may not be viable.

This is, therefore, a very serious problem. Investments that are a priori profitable may have problems of viability, usually due to financing problems.

The term already used of cash flow becomes fundamental to explain these concepts. For the investment to be profitable, it is only necessary that the benefits be greater than the costs, but in order for a certain investment to be made, funds must be available.

The overall calculation of an investment needs a provision of funds. The investment can be fully assumed by the investor without the need of third parties or on the contrary it may require external financing (from banks normally), which can help provide the liquidity that allows the final viability of the project.

It is a variant of traditional financing in which the profitability of the project is analyzed and, depending on this, the financial institution assumes the investment risk.

The net results of the investment are also used to pay the loan. Here the guarantee of financing is given by the investment itself, in this case, the energy savings.

This type of financing does not allow return periods of more than seven years, and the interest rate is slightly higher than normal loans, such as investment risk premium.

Its great advantage is the treatment as an off-balance-sheet operation, which allows companies to not compromise their solvency ratios, by not counting the amount of financing as a liability.

10. Example of development of the NPV / TIR for an energy improvement

To better explain the process of calculating the NPV and TIR, the following example is proposed with a specific energy saving measure, such as the improvement of the thermal insulation of the heating pipe networks and A.C.S.

Due to the great distances that run through the networks of heating and sanitary hot water pipes, it is essential that its thermal insulation be fully effective.

It is part of a building with a high thermal inertia in which there are numerous complaints from the neighbors of the upper floors in relation to heating. The initial situation starts with a very poor insulation since in many sections it is detached and in others it does not exist, besides having a thickness below the one that marks the RITE (Regulation of Thermal Installations in Buildings) for this use in its IT 1.2 .4.2, and that is as follows:

DIÁMETRO EXTERIOR (mm)	TEMPERATURA MÁXIMA DEL FLUIDO (ºC)		
	40...60	> 60...100	> 100...180
D ≤ 35	25	25	30
35 < D ≤ 60	30	30	40
60 < D ≤ 90	30	30	40
90 < D ≤ 140	30	40	50
140 < D	35	40	5

Currently the building has 9mm of pipe insulation when in fact it corresponds 30mm according to the RITE.

The heat losses of each insulation are:

DIÁMETRO EXTERIOR	SALTO TÉRMICO	PÉRDIDAS DE CALOR EN TUBERÍAS (W/m)		
(mm)	(ºC)	ESPESOR DEL AISLAMIENTO (mm) (I=0,036 W/mK)		
		Para 10 mm	Para 30 mm	Diferencia o ahorro
60	20	12,4	6,1	6,3
76	20	15,1	7,2	7,9

The building has 464 meters of 76mm pipe and it is assumed that the bad state of the insulation increases up to 30% the savings with the new installation. A thermal jump of 20 ° C is assumed.

It is assumed a use of 14hr a day for 180 days a year. The fuel expense is 0.08 € / kwh in diesel. It is assumed an increase of 2% per year in the cost of diesel.

The budget of the new facility amounts to 7786 euros and the% discount rate or opportunity cost is 5.03%.

Pérdidas energéticas	7,9 + 30% estimado de trazado en mal estado 10,27 W/mK
Longitud total de tubería a sustituir (m)	464,4
Total pérdidas (W/mK), (A x B)	4.769,4
Total pérdidas (kW)	**4,8**
Horas de uso al día	14
Días al año de uso	180
kW ahorrados por temporada	12.018,86
Coste del Gasóleo (€)	0,08

The calculation of the gross amortization period, which has already been explained above, is made with investment values (€ 7786) and net annual savings (€ 961.51). In this case, the amortization period is 5.9 years. It is therefore a profitable operation in the medium term taking into account that the useful life of the new isolations could be considered as a minimum of 15 years.

Ahorro anual (€), (G x H)	961,51
Presupuesto estimado de ejecución (€)	7.786,00 €
Período Retorno (años)	5,9

We proceed now to the development of the NPV and TIR equations. In a first case, it is going to be assumed that the investment will be made without having to ask for a loan, that is, with its own financing.

In this case, the calculation is made at 25 years.

The first 3 columns (usual expenses, expenses, improvements and other expenses) will allow calculating the base of the cash flow of each year.

In the usual expenses column, in this case, the present expenses are introduced, with the current situation starting from year 1, which is the first in which the measure is implemented.

The example deals with annual energy losses in euros. As can be seen each year, these losses are greater due to the increase of 2% that has been raised as an assumption of the evolution of fuel prices.

AÑO	GASTOS HABITUALES	GASTOS MEJORAS	OTROS GASTOS	Pendiente Amortizar Crédito	CUOTA CRÉDITO	AMORTIZADO	INTERESES PAGADOS	TOTAL GASTOS ANUALES	CASH-FLOW	CASH FLOW ACUMULADO	CASH-FLOW ACTUALIZADO
Año 0		7.786,00 €						7.786,00 €	-7.786,00 €	-7.786,00 €	-7.786,00 €
Año 1	961,44 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	961,44 €	-6.824,56 €	915,40 €
Año 2	980,67 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	980,67 €	-5.843,89 €	888,99 €
Año 3	1.000,28 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.000,28 €	-4.843,61 €	863,34 €
Año 4	1.020,29 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.020,29 €	-3.823,32 €	838,43 €
Año 5	1.040,69 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.040,69 €	-2.782,63 €	814,25 €
Año 6	1.061,51 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.061,51 €	-1.721,12 €	790,76 €
Año 7	1.082,74 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.082,74 €	-638,38 €	767,94 €
Año 8	1.104,39 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.104,39 €	466,01 €	745,79 €
Año 9	1.126,48 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.126,48 €	1.592,49 €	724,27 €
Año 10	1.149,01 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.149,01 €	2.741,50 €	703,38 €
Año 11	1.171,99 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.171,99 €	3.913,49 €	683,09 €
Año 12	1.195,43 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.195,43 €	5.108,92 €	663,38 €
Año 13	1.219,34 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.219,34 €	6.328,26 €	644,24 €
Año 14	1.243,73 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.243,73 €	7.571,98 €	625,66 €
Año 15	1.268,60 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.268,60 €	8.840,58 €	607,61 €
Año 16	1.293,97 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.293,97 €	10.134,55 €	590,08 €
Año 17	1.319,85 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.319,85 €	11.454,41 €	573,06 €
Año 18	1.346,25 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.346,25 €	12.800,65 €	556,52 €
Año 19	1.373,17 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.373,17 €	14.173,83 €	540,47 €
Año 20	1.400,64 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.400,64 €	15.574,46 €	524,88 €
Año 21	1.428,65 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.428,65 €	17.003,11 €	509,74 €
Año 22	1.457,22 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.457,22 €	18.460,33 €	495,03 €
Año 23	1.486,37 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.486,37 €	19.946,70 €	480,75 €
Año 24	1.516,09 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.516,09 €	21.462,80 €	466,88 €
Año 25	1.546,42 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.546,42 €	23.009,21 €	453,41 €

In the expenses improvement column, in this case, future expenses are introduced with the improved situation. In the example, they are 0 since it is assumed that with the measure the energy losses will not exist. The initial investment of € 7786 is introduced in year 0, which is the moment in which the measure is made.

AÑO	GASTOS HABITUALES	GASTOS MEJORAS	OTROS GASTOS	Pendiente Amortizar Crédito	CUOTA CRÉDITO	AMORTIZADO	INTERESES PAGADOS	TOTAL GASTOS ANUALES	CASH-FLOW	CASH FLOW ACUMULADO	CASH-FLOW ACTUALIZADO
Año 0		7.786,00 €						7.786,00 €	-7.786,00 €	-7.786,00 €	-7.786,00 €
Año 1	961,44 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	961,44 €	-6.824,56 €	915,40 €
Año 2	980,67 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	980,67 €	-5.843,89 €	888,99 €
Año 3	1.000,28 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.000,28 €	-4.843,61 €	863,34 €
Año 4	1.020,29 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.020,29 €	-3.823,32 €	838,43 €
Año 5	1.040,69 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.040,69 €	-2.782,63 €	814,25 €
Año 6	1.061,51 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.061,51 €	-1.721,12 €	790,76 €
Año 7	1.082,74 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.082,74 €	-638,38 €	767,94 €
Año 8	1.104,39 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.104,39 €	466,01 €	745,79 €
Año 9	1.126,48 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.126,48 €	1.592,49 €	724,27 €
Año 10	1.149,01 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.149,01 €	2.741,50 €	703,38 €
Año 11	1.171,99 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.171,99 €	3.913,49 €	683,09 €
Año 12	1.195,43 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.195,43 €	5.108,92 €	663,38 €
Año 13	1.219,34 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.219,34 €	6.328,26 €	644,24 €
Año 14	1.243,73 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.243,73 €	7.571,98 €	625,66 €
Año 15	1.268,60 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.268,60 €	8.840,58 €	607,61 €
Año 16	1.293,97 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.293,97 €	10.134,55 €	590,08 €
Año 17	1.319,85 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.319,85 €	11.454,41 €	573,06 €
Año 18	1.346,25 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.346,25 €	12.800,65 €	556,52 €
Año 19	1.373,17 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.373,17 €	14.173,83 €	540,47 €
Año 20	1.400,64 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.400,64 €	15.574,46 €	524,88 €
Año 21	1.428,65 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.428,65 €	17.003,11 €	509,74 €
Año 22	1.457,22 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.457,22 €	18.460,33 €	495,03 €
Año 23	1.486,37 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.486,37 €	19.946,70 €	480,75 €
Año 24	1.516,09 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.516,09 €	21.462,80 €	466,88 €
Año 25	1.546,42 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.546,42 €	23.009,21 €	453,41 €

The other expenses column is left open if new maintenance and license expenses are generated with the new measure ... In the example, they are left at 0 since no new expenses are assumed.

AÑO	GASTOS HABITUALES	GASTOS MEJORAS	OTROS GASTOS	Pendiente Amortizar Crédito	CUOTA CRÉDITO	AMORTIZADO	INTERESES PAGADOS	TOTAL GASTOS ANUALES	CASH-FLOW	CASH FLOW ACUMULADO	CASH-FLOW ACTUALIZADO
Año 0		7.786,00 €						7.786,00 €	-7.786,00 €	-7.786,00 €	-7.786,00 €
Año 1	961,44 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	961,44 €	-6.824,56 €	915,40 €
Año 2	980,67 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	980,67 €	-5.843,89 €	888,99 €
Año 3	1.000,28 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.000,28 €	-4.843,61 €	863,34 €
Año 4	1.020,29 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.020,29 €	-3.823,32 €	838,43 €
Año 5	1.040,69 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.040,69 €	-2.782,63 €	814,25 €
Año 6	1.061,51 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.061,51 €	-1.721,12 €	790,76 €
Año 7	1.082,74 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.082,74 €	-638,38 €	767,94 €
Año 8	1.104,39 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.104,39 €	466,01 €	745,79 €
Año 9	1.126,48 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.126,48 €	1.592,49 €	724,27 €
Año 10	1.149,01 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.149,01 €	2.741,50 €	703,38 €
Año 11	1.171,99 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.171,99 €	3.913,49 €	683,09 €
Año 12	1.195,43 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.195,43 €	5.108,92 €	663,38 €
Año 13	1.219,34 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.219,34 €	6.328,26 €	644,24 €
Año 14	1.243,73 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.243,73 €	7.571,98 €	625,66 €
Año 15	1.268,60 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.268,60 €	8.840,58 €	607,61 €
Año 16	1.293,97 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.293,97 €	10.134,55 €	590,08 €
Año 17	1.319,85 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.319,85 €	11.454,41 €	573,06 €
Año 18	1.346,25 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.346,25 €	12.800,65 €	556,52 €
Año 19	1.373,17 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.373,17 €	14.173,83 €	540,47 €
Año 20	1.400,64 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.400,64 €	15.574,46 €	524,88 €
Año 21	1.428,65 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.428,65 €	17.003,11 €	509,74 €
Año 22	1.457,22 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.457,22 €	18.460,33 €	495,03 €
Año 23	1.486,37 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.486,37 €	19.946,70 €	480,75 €
Año 24	1.516,09 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.516,09 €	21.462,80 €	466,88 €
Año 25	1.546,42 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.546,42 €	23.009,21 €	453,41 €

The next 4 columns analyze external financing assuming that there can be a bank loan. In this example, it has been assumed that the € 7,786 is covered by own resources, but it is clear that, in some cases, the request for credit could be raised at a% interest.

In this case, the first column is the amount pending amortization, the second is the annual installment of the outstanding loan based on the bank interest, the third is the value of the annual amortization and the fourth is the interest paid to the bank in the current year.

In the example, when assuming own resources, the value is in all columns 0, but if this is not the case, the column of the fee paid annually would be added as future expenses to the initial investment.

AÑO	GASTOS HABITUALES	GASTOS MEJORAS	OTROS GASTOS	Pendiente Amortizar Crédito	CUOTA CRÉDITO	AMORTIZADO	INTERESES PAGADOS	TOTAL GASTOS ANUALES	CASH-FLOW	CASH FLOW ACUMULADO	CASH-FLOW ACTUALIZADO
Año 0		7.786,00 €						7.786,00 €	-7.786,00 €	-7.786,00 €	-7.786,00 €
Año 1	961,44 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	961,44 €	-6.824,56 €	915,40 €
Año 2	980,67 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	980,67 €	-5.843,89 €	888,99 €
Año 3	1.000,28 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.000,28 €	-4.843,61 €	863,34 €
Año 4	1.020,29 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.020,29 €	-3.823,32 €	838,43 €
Año 5	1.040,69 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.040,69 €	-2.782,63 €	814,25 €
Año 6	1.061,51 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.061,51 €	-1.721,12 €	790,76 €
Año 7	1.082,74 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.082,74 €	-638,38 €	767,94 €
Año 8	1.104,39 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.104,39 €	466,01 €	745,79 €
Año 9	1.126,48 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.126,48 €	1.592,49 €	724,27 €
Año 10	1.149,01 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.149,01 €	2.741,50 €	703,38 €
Año 11	1.171,99 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.171,99 €	3.913,49 €	683,09 €
Año 12	1.195,43 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.195,43 €	5.108,92 €	663,38 €
Año 13	1.219,34 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.219,34 €	6.328,26 €	644,24 €
Año 14	1.243,73 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.243,73 €	7.571,98 €	625,66 €
Año 15	1.268,60 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.268,60 €	8.840,58 €	607,61 €
Año 16	1.293,97 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.293,97 €	10.134,55 €	590,08 €
Año 17	1.319,85 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.319,85 €	11.454,41 €	573,06 €
Año 18	1.346,25 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.346,25 €	12.800,65 €	556,52 €
Año 19	1.373,17 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.373,17 €	14.173,83 €	540,47 €
Año 20	1.400,64 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.400,64 €	15.574,46 €	524,88 €
Año 21	1.428,65 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.428,65 €	17.003,11 €	509,74 €
Año 22	1.457,22 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.457,22 €	18.460,33 €	495,03 €
Año 23	1.486,37 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.486,37 €	19.946,70 €	480,75 €
Año 24	1.516,09 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.516,09 €	21.462,80 €	466,88 €
Año 25	1.546,42 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.546,42 €	23.009,21 €	453,41 €

The column TOTAL ANNUAL EXPENSES will therefore be the sum of the column IMPROVEMENTS EXPENSES + OTHER EXPENSES + CREDIT QUOTA (in case this exists).

The annual CASH-FLOW column (cash flow) which is the value of the numerator in the formula of the NPV calculation (F1, F2, F3 ... F25) will be the difference between the HABITUAL EXPENSES and the TOTAL ANNUAL EXPENSES.

$$VAN = -I_0 + \sum_{t=1}^{n} \frac{\boxed{F_t}}{(1+k)^t} = -I_0 + \frac{\boxed{F_1}}{(1+k)} + \frac{\boxed{F_2}}{(1+k)^2} + \cdots + \frac{\boxed{F_n}}{(1+k)^n}$$

AÑO	GASTOS HABITUALES	GASTOS MEJORAS	OTROS GASTOS	Pendiente Amortizar Crédito	CUOTA CRÉDITO	AMORTIZADO	INTERESES PAGADOS	TOTAL GASTOS ANUALES	CASH-FLOW	CASH FLOW ACUMULADO	CASH-FLOW ACTUALIZADO
Año 0		7.786,00 €						7.786,00 €	-7.786,00 €	-7.786,00 €	-7.786,00 €
Año 1	961,44 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	961,44 €	-6.824,56 €	915,40 €
Año 2	980,67 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	980,67 €	-5.843,89 €	888,99 €
Año 3	1.000,28 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.000,28 €	-4.843,61 €	863,34 €
Año 4	1.020,29 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.020,29 €	-3.823,32 €	838,43 €
Año 5	1.040,69 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.040,69 €	-2.782,63 €	814,25 €
Año 6	1.061,51 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.061,51 €	-1.721,12 €	790,76 €
Año 7	1.082,74 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.082,74 €	-638,38 €	767,94 €
Año 8	1.104,39 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.104,39 €	466,01 €	745,79 €
Año 9	1.126,48 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.126,48 €	1.592,49 €	724,27 €
Año 10	1.149,01 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.149,01 €	2.741,50 €	703,38 €
Año 11	1.171,99 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.171,99 €	3.913,49 €	683,09 €
Año 12	1.195,43 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.195,43 €	5.108,92 €	663,38 €
Año 13	1.219,34 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.219,34 €	6.328,26 €	644,24 €
Año 14	1.243,73 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.243,73 €	7.571,98 €	625,66 €
Año 15	1.268,60 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.268,60 €	8.840,58 €	607,61 €
Año 16	1.293,97 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.293,97 €	10.134,55 €	590,08 €
Año 17	1.319,85 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.319,85 €	11.454,41 €	573,06 €
Año 18	1.346,25 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.346,25 €	12.800,65 €	556,52 €
Año 19	1.373,17 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.373,17 €	14.173,83 €	540,47 €
Año 20	1.400,64 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.400,64 €	15.574,46 €	524,88 €
Año 21	1.428,65 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.428,65 €	17.003,11 €	509,74 €
Año 22	1.457,22 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.457,22 €	18.460,33 €	495,03 €
Año 23	1.486,37 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.486,37 €	19.946,70 €	480,75 €
Año 24	1.516,09 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.516,09 €	21.462,80 €	466,88 €
Año 25	1.546,42 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.546,42 €	23.009,21 €	453,41 €

The CASH-FLOW ACCUMULATED column is simply the sum of the annual CASH-FLOW without updating at the present time. That is, without applying the discount rate or opportunity cost. It is merely informative.

AÑO	GASTOS HABITUALES	GASTOS MEJORAS	OTROS GASTOS	Pendiente Amortizar Crédito	CUOTA CRÉDITO	AMORTIZADO	INTERESES PAGADOS	TOTAL GASTOS ANUALES	CASH-FLOW	CASH FLOW ACUMULADO	CASH-FLOW ACTUALIZADO
Año 0		7.786,00 €						7.786,00 €	-7.786,00 €	-7.786,00 €	-7.786,00 €
Año 1	961,44 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	961,44 €	-6.824,56 €	915,40 €
Año 2	980,67 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	980,67 €	-5.843,89 €	888,99 €
Año 3	1.000,28 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.000,28 €	-4.843,61 €	863,34 €
Año 4	1.020,29 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.020,29 €	-3.823,32 €	838,43 €
Año 5	1.040,69 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.040,69 €	-2.782,63 €	814,25 €
Año 6	1.061,51 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.061,51 €	-1.721,12 €	790,76 €
Año 7	1.082,74 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.082,74 €	-638,38 €	767,94 €
Año 8	1.104,39 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.104,39 €	466,01 €	745,79 €
Año 9	1.126,48 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.126,48 €	1.592,49 €	724,27 €
Año 10	1.149,01 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.149,01 €	2.741,50 €	703,38 €
Año 11	1.171,99 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.171,99 €	3.913,49 €	683,09 €
Año 12	1.195,43 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.195,43 €	5.108,92 €	663,38 €
Año 13	1.219,34 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.219,34 €	6.328,26 €	644,24 €
Año 14	1.243,73 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.243,73 €	7.571,98 €	625,66 €
Año 15	1.268,60 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.268,60 €	8.840,58 €	607,61 €
Año 16	1.293,97 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.293,97 €	10.134,55 €	590,08 €
Año 17	1.319,85 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.319,85 €	11.454,41 €	573,06 €
Año 18	1.346,25 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.346,25 €	12.800,65 €	556,52 €
Año 19	1.373,17 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.373,17 €	14.173,83 €	540,47 €
Año 20	1.400,64 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.400,64 €	15.574,46 €	524,88 €
Año 21	1.428,65 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.428,65 €	17.003,11 €	509,74 €
Año 22	1.457,22 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.457,22 €	18.460,33 €	495,03 €
Año 23	1.486,37 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.486,37 €	19.946,70 €	480,75 €
Año 24	1.516,09 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.516,09 €	21.462,80 €	466,88 €
Año 25	1.546,42 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.546,42 €	23.009,21 €	453,41 €

Finally, the CASH-FLOW UPDATED column calculates the value of the individual terms of the calculation formula of the NPV. Therefore, the value used as a discount rate or opportunity cost (k = 5.03% according to the statement) appears.

$$VAN = -I_0 + \sum_{t=1}^{n} \boxed{\frac{F_t}{(1+k)^t}} = -I_0 + \boxed{\frac{F_1}{(1+k)}} + \boxed{\frac{F_2}{(1+k)^2}} + \cdots + \boxed{\frac{F_n}{(1+k)^n}}$$

AÑO	GASTOS HABITUALES	GASTOS MEJORAS	OTROS GASTOS	Pendiente Amortizar Crédito	CUOTA CRÉDITO	AMORTIZADO	INTERESES PAGADOS	TOTAL GASTOS ANUALES	CASH-FLOW	CASH FLOW ACUMULADO	CASH-FLOW ACTUALIZADO
Año 0		7.786,00 €						7.786,00 €	-7.786,00 €	-7.786,00 €	-7.786,00 €
Año 1	961,44 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	961,44 €	-6.824,56 €	915,40 €
Año 2	980,67 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	980,67 €	-5.843,89 €	888,99 €
Año 3	1.000,28 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.000,28 €	-4.843,61 €	863,34 €
Año 4	1.020,29 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.020,29 €	-3.823,32 €	838,43 €
Año 5	1.040,69 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.040,69 €	-2.782,63 €	814,25 €
Año 6	1.061,51 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.061,51 €	-1.721,12 €	790,76 €
Año 7	1.082,74 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.082,74 €	-638,38 €	767,94 €
Año 8	1.104,39 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.104,39 €	466,01 €	745,79 €
Año 9	1.126,48 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.126,48 €	1.592,49 €	724,27 €
Año 10	1.149,01 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.149,01 €	2.741,50 €	703,38 €
Año 11	1.171,99 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.171,99 €	3.913,49 €	683,09 €
Año 12	1.195,43 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.195,43 €	5.108,92 €	663,38 €
Año 13	1.219,34 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.219,34 €	6.328,26 €	644,24 €
Año 14	1.243,73 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.243,73 €	7.571,98 €	625,66 €
Año 15	1.268,60 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.268,60 €	8.840,58 €	607,61 €
Año 16	1.293,97 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.293,97 €	10.134,55 €	590,08 €
Año 17	1.319,85 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.319,85 €	11.454,41 €	573,06 €
Año 18	1.346,25 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.346,25 €	12.800,65 €	556,52 €
Año 19	1.373,17 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.373,17 €	14.173,83 €	540,47 €
Año 20	1.400,64 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.400,64 €	15.574,46 €	524,88 €
Año 21	1.428,65 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.428,65 €	17.003,11 €	509,74 €
Año 22	1.457,22 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.457,22 €	18.460,33 €	495,03 €
Año 23	1.486,37 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.486,37 €	19.946,70 €	480,75 €
Año 24	1.516,09 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.516,09 €	21.462,80 €	466,88 €
Año 25	1.546,42 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1.546,42 €	23.009,21 €	453,41 €

At this time, all the cash flows updated at present time are already available with the discount rate applied to each annual balance.

The NPV formula is simply the sum of the CASH-FLOW UPDATED column for the year you want to calculate.

In other words, to calculate the NPV in year 2, the CASH-FLOW UPDATED for year 0 (-7,786 €) + CASH-FLOW UPDATED for year 1 (€ 915.4) + CASH-FLOW UPDATED for the year would have to be added. Year 2 (€ 88.99).

If this summation is made for all years we have the NPV in each year in progress.

AÑO	VAN
Año 0	-7.786,00 €
Año 1	-6.870,60 €
Año 2	-5.981,62 €
Año 3	-5.118,28 €
Año 4	-4.279,84 €
Año 5	-3.465,59 €
Año 6	-2.674,84 €
Año 7	-1.906,89 €
Año 8	-1.161,10 €
Año 9	-436,83 €
Año 10	266,55 €
Año 11	949,64 €
Año 12	1.613,02 €
Año 13	2.257,27 €
Año 14	2.882,92 €
Año 15	3.490,53 €
Año 16	4.080,61 €
Año 17	4.653,67 €
Año 18	5.210,19 €
Año 19	5.750,66 €
Año 20	6.275,54 €
Año 21	6.785,28 €
Año 22	7.280,31 €
Año 23	7.761,06 €
Año 24	8.227,94 €
Año 25	8.681,35 €

With these values, it can be seen that in year 25 the benefit provided by the measure is € 8,681.35. If the useful life of the measure is reduced to 15 years, the NPV in that period of time would be € 3,490.52.

The IRR, as explained above, is the modification of the NPV equation so that it gives a value 0. As you can see, that value of NPV 0 is given for year 10. From year 10 the value of the IRR will be positive and, therefore, the investment will be profitable. It must be borne in mind that, if the IRR value is 0, it does not mean that the investment has simply been recovered, but that a% benefit similar to the applied discount rate has been achieved (in this case, 5.03%)

The TIR is complicated to simulate in EXCEL but you can use the TIR function in the excel, as already explained, for each year, so that you get the following values: The first values give an error because the function has incongruent parameters.

AÑO	TIR	VAN
Año 0		-7.786,00 €
Año 1	#¡NUM!	-6.870,60 €
Año 2	#¡NUM!	-5.981,62 €
Año 3	#¡NUM!	-5.118,28 €
Año 4	-26,00%	-4.279,84 €
Año 5	-17,16%	-3.465,59 €
Año 6	-11,08%	-2.674,84 €
Año 7	-6,75%	-1.906,89 €
Año 8	-3,57%	-1.161,10 €
Año 9	-1,18%	-436,83 €
Año 10	0,65%	266,55 €
Año 11	2,07%	949,64 €
Año 12	3,21%	1.613,02 €
Año 13	4,11%	2.257,27 €
Año 14	4,85%	2.882,92 €
Año 15	5,46%	3.490,53 €
Año 16	5,96%	4.080,61 €
Año 17	6,37%	4.653,67 €
Año 18	6,72%	5.210,19 €
Año 19	7,01%	5.750,66 €
Año 20	7,26%	6.275,54 €
Año 21	7,47%	6.785,28 €
Año 22	7,65%	7.280,31 €
Año 23	7,81%	7.761,06 €
Año 24	7,94%	8.227,94 €
Año 25	8,06%	8.681,35 €

Values of NPV and IRR for discount rate of 5.03%

At first glance, it could be said that it is important to check the difference between a present-time indicator, such as the gross amortization period (which gave a return in 6 years), and a future time indicator, which uses more calculation variables and that gives us a return on investment 4 years higher.

This statement is real, but in this case it is a misleading result because the IRR becomes 0 for a discount rate of 5.03% while the gross amortization period implies a discount rate of 0%. In order to compare homogeneous results it is necessary to compare the table of the NPV and IRR for a discount rate of 0%.

The results would be the following:

0,00%			
CASH-FLOW ACTUALIZADO	AÑO	TIR	VAN
-7.786,00 €	Año 0		-7.786,00 €
961,44 €	Año 1	#¡NUM!	-6.824,56 €
980,67 €	Año 2	#¡NUM!	-5.843,89 €
1.000,28 €	Año 3	#¡NUM!	-4.843,61 €
1.020,29 €	Año 4	-22,27%	-3.823,32 €
1.040,69 €	Año 5	-12,99%	-2.782,63 €
1.061,51 €	Año 6	-6,60%	-1.721,12 €
1.082,74 €	Año 7	-2,05%	-638,38 €
1.104,39 €	Año 8	1,28%	466,01 €
1.126,48 €	Año 9	3,79%	1.592,49 €
1.149,01 €	Año 10	5,71%	2.741,50 €
1.171,99 €	Año 11	7,21%	3.913,49 €
1.195,43 €	Año 12	8,40%	5.108,92 €
1.219,34 €	Año 13	9,35%	6.328,26 €
1.243,73 €	Año 14	10,13%	7.571,98 €
1.268,60 €	Año 15	10,76%	8.840,58 €
1.293,97 €	Año 16	11,28%	10.134,55 €
1.319,85 €	Año 17	11,72%	11.454,41 €
1.346,25 €	Año 18	12,09%	12.800,65 €
1.373,17 €	Año 19	12,39%	14.173,83 €
1.400,64 €	Año 20	12,66%	15.574,46 €
1.428,65 €	Año 21	12,88%	17.003,11 €
1.457,22 €	Año 22	13,07%	18.460,33 €
1.486,37 €	Año 23	13,23%	19.946,70 €
1.516,09 €	Año 24	13,37%	21.462,80 €
1.546,42 €	Año 25	13,49%	23.009,21 €

Values of NPV and IRR for discount rate of 0%

In this case, the value of the NPV becomes positive in year 8 (it was done in 10 for k = 5.03%); is closer to the calculated amortization period of 6 years.

These results are comparable, and hence the importance of making a feasibility analysis using and updating future variables to the present time, since the final data may be ostensibly different.

To finish the example, it is going to be assumed that a loan is requested from the bank for the amount of 50% (€ 3893) at an interest rate of 5% per year over a period of 20 years.

The columns referring to bank credit are those that are modified and would be as follows:

AÑO	GASTOS HABITUALES	GASTOS MEJORAS	OTROS GASTOS	CUOTA CRÉDITO	TOTAL GASTOS ANUALES	CASH-FLOW	CASH FLOW ACUMULADO	CASH-FLOW ACTUALIZADO	TIR	VAN
Año 0		3.893,00 €			3.893,00 €	-3.893,00 €	-3.893,00 €	-3.893,00 €		-3.893,00 €
Año 1	961,44 €	0,00 €	0,00 €	389,30 €	389,30 €	572,14 €	-3.320,86 €	544,74 €	#¡NUM!	-3.348,26 €
Año 2	980,67 €	0,00 €	0,00 €	379,57 €	379,57 €	601,10 €	-2.719,76 €	544,91 €	#¡NUM!	-2.803,36 €
Año 3	1.000,28 €	0,00 €	0,00 €	369,84 €	369,84 €	630,45 €	-2.089,31 €	544,14 €	-33,43%	-2.259,22 €
Año 4	1.020,29 €	0,00 €	0,00 €	360,10 €	360,10 €	660,19 €	-1.429,13 €	542,52 €	-19,80%	-1.716,70 €
Año 5	1.040,69 €	0,00 €	0,00 €	350,37 €	350,37 €	690,32 €	-738,80 €	540,11 €	-10,92%	-1.176,59 €
Año 6	1.061,51 €	0,00 €	0,00 €	340,64 €	340,64 €	720,87 €	-17,93 €	537,00 €	-4,91%	-639,58 €
Año 7	1.082,74 €	0,00 €	0,00 €	330,91 €	330,91 €	751,83 €	733,90 €	533,25 €	-0,69%	-106,34 €
Año 8	1.104,39 €	0,00 €	0,00 €	321,17 €	321,17 €	783,22 €	1.517,12 €	528,90 €	2,36%	422,57 €
Año 9	1.126,48 €	0,00 €	0,00 €	311,44 €	311,44 €	815,04 €	2.332,16 €	524,03 €	4,62%	946,60 €
Año 10	1.149,01 €	0,00 €	0,00 €	301,71 €	301,71 €	847,30 €	3.179,46 €	518,69 €	6,33%	1.465,28 €
Año 11	1.171,99 €	0,00 €	0,00 €	291,98 €	291,98 €	880,01 €	4.059,48 €	512,91 €	7,65%	1.978,20 €
Año 12	1.195,43 €	0,00 €	0,00 €	282,24 €	282,24 €	913,19 €	4.972,66 €	506,76 €	8,68%	2.484,95 €
Año 13	1.219,34 €	0,00 €	0,00 €	272,51 €	272,51 €	946,83 €	5.919,49 €	500,26 €	9,49%	2.985,22 €
Año 14	1.243,73 €	0,00 €	0,00 €	262,78 €	262,78 €	980,95 €	6.900,44 €	493,47 €	10,14%	3.478,68 €
Año 15	1.268,60 €	0,00 €	0,00 €	253,05 €	253,05 €	1.015,55 €	7.916,00 €	486,41 €	10,66%	3.965,09 €
Año 16	1.293,97 €	0,00 €	0,00 €	243,31 €	243,31 €	1.050,66 €	8.966,65 €	479,12 €	11,09%	4.444,22 €
Año 17	1.319,85 €	0,00 €	0,00 €	233,58 €	233,58 €	1.086,27 €	10.052,93 €	471,64 €	11,44%	4.915,86 €
Año 18	1.346,25 €	0,00 €	0,00 €	223,85 €	223,85 €	1.122,40 €	11.175,33 €	463,99 €	11,72%	5.379,85 €
Año 19	1.373,17 €	0,00 €	0,00 €	214,12 €	214,12 €	1.159,06 €	12.334,38 €	456,20 €	11,96%	5.836,04 €
Año 20	1.400,64 €	0,00 €	0,00 €	204,38 €	204,38 €	1.196,25 €	13.530,64 €	448,29 €	12,16%	6.284,33 €
Año 21	1.428,65 €	0,00 €	0,00 €	194,65 €	194,65 €	1.234,00 €	14.764,64 €	440,29 €	12,32%	6.724,61 €
Año 22	1.457,22 €	0,00 €	0,00 €	0,00 €	0,00 €	1.457,22 €	16.221,86 €	495,03 €	12,48%	7.219,65 €
Año 23	1.486,37 €	0,00 €	0,00 €	0,00 €	0,00 €	1.486,37 €	17.708,23 €	480,75 €	12,61%	7.700,39 €
Año 24	1.516,09 €	0,00 €	0,00 €	0,00 €	0,00 €	1.516,09 €	19.224,32 €	466,88 €	12,72%	8.167,27 €
Año 25	1.546,42 €	0,00 €	0,00 €	0,00 €	0,00 €	1.546,42 €	20.770,74 €	453,41 €	12,81%	8.620,69 €

The values of NPV and IRR obviously change due to a new annual expense which is the share of the satisfied credit that must be added to the columns EXPENDITURE EXPENSES + OTHER EXPENSES.

The NPV is somewhat lower and the IRR is also, although it is not too noticeable since the credit amount is quite small.

Unit 3: Examples of feasibility study, calculation of savings and amortization period of actions

1. Process of calculation of profitability of an energy efficiency measure

The process of calculating the profitability of an energy efficiency measure can be broken down into several work phases:

1. Approach of the measure

2. Calculation of the INITIAL AND FINAL demand of heating and cooling energy

3. Calculation of the INITIAL and FINAL average seasonal performance of the installation of heat and cold

4. Calculation of the contribution of renewable energies INITIAL AND FINAL

5. Calculation of INITIAL and FINAL non-renewable primary energy consumption.

6. Evolution of fuel prices.

7. Calculation of ECONOMIC SAVINGS between INITIAL and FINAL situation.

8. Valuation of the investment: EQUIPMENT, MATERIALS, LABOR...

9. Estimation of the future evolution of important variables in the economic analysis: CPI, interest rates...

10. Assessment of the possibility of subsidies, external financing, credits...

11. Final economic and viability analysis: Amortization period, NPV, IRR...

The INITIAL and FINAL values are comparable to the PRESENT and FUTURE values, BEFORE the rehabilitation and AFTER.

P1. Approach of the measure

The first point is to determine what is the measure (or set of measures) of energy efficiency that you want to implement in the rehabilitation.

The spectrum of energy solutions is very broad but can be included in three blocks:

- Measures to reduce the demand for energy

- Measures to increase the performance of the facilities

- Measures for the contribution of renewable energies

Acting on any of the 3 variables allows reducing the consumption of non-renewable energy, the objective of all energy efficiency measures.

$$C\ (Consumodeenergíanorenovable) = \frac{D\ (Demandadeenergía)}{R\ (Rendimientodelasinstalaciones)} - EERR$$

The measures to reduce energy demand are mainly based on the reduction of energy losses in the building envelope (walls, windows, doors ...). Among them, the following could be highlighted:

- Improvement of the thermal insulation of enclosures
- Improvement of the thermal behavior of doors and windows
- Reduction of losses in pipes
- Reduction of air infiltrations
- Parameters of eco-design: orientation, shadows, protections...
- Thermal bridges

In terms of facilities, the measures are based on increasing the average seasonal performance of the facilities. For example by incorporating:

- More efficient heat pumps
- Condensing or low temperature boilers instead of conventional
- Reduction of the nominal power of the machines

- Use of heat recovery units or free cooling systems

- Replacing conventional lamps with LED

Finally, another way to achieve the required demand is through the support of renewable energies by reducing the consumption of non-renewable primary energy. For example:

- Higher contribution of solar thermal energy

- Change of fuel to biomass

- Generation of electrical energy through photovoltaic panels

- Use of geothermal or aerothermal heat pumps.

P2. Calculation of the INITIAL AND FINAL demand of heating and cooling energy

It is a complicated calculation, because it is a multivariate analysis with the external temperature and the load of use as more variable parameters.

The current consumption of the building is easily verifiable through your invoices. What is really complex to simulate is the saving that supposes, for example, to isolate the facades or to change the windows.

To do this, computer models are used, more or less complex, that simulate the thermal behavior of the building. The usual procedure, after modeling the building in any program, is to make an adjustment of your consumptions to the actual invoices collected in a representative period of time, between 1 and 5 years, so that a computer simulation is procured as close as possible to reality.

In Spain there are several software that allow this calculation, some of them recognized by the Ministry of Industry for the calculation of demand: Unified tool LIDER and CALENER, CE3X, CEX....

For example, HULC, the unified tool LIDER-CALENER (accepted programs for limiting energy demand and energy rating of the building) that simulate the variation of thermal demands are computed in periods of 1 hour, which entails establishing the thermal balance of the building for a total of 365 days x 24 hours = 8,760 states.

There are also other specific commercial programs for calculating energy demand (CYPE, Energy + ...). They are based on the schedule method Standard pr-EN-13790-2005 on calculation of energy demand. They also work with 365 days x 24 hours = 8,760 states.

It is about comparing the energy demand required prior to the implementation of the measure with the necessary one after the rehabilitation.

HULC is recommended because it is the official program more adjusted to reality and to use a time simulation.

Monthly estimation is not recommended because it loses a lot of information.

> *The energy saving in demand will therefore be:*
>
> *Energy Demand Previous Status - Energy Demand Final State.*

This saving must be transformed subsequently into a reduction in the consumption of non-renewable primary energy and in economic savings.

P3. Calculation of the INITIAL and FINAL average seasonal performance of the installation of heat and cold

The nominal performance of a device is the maximum performance (load factor of 100%) in optimal conditions established by the manufacturer.

It is the maximum power that the team is capable of generating, but it does not characterize the annual operation.

For example, if a boiler has a nominal power of 25 kW, it means that this is the maximum it can develop. But it is not the average operating value of the equipment throughout the year.

The value that must be used to calculate the annual energy consumption (kWh / year) is the average seasonal yield.

The calculation of the average seasonal performance of a cold or heat equipment is quite complicated but can be approximated as follows:

<u>AVERAGE SEASONAL PERFORMANCE IN BOILERS</u>

RENDIMIENTO ESTACIONAL MEDIO EN CALDERAS	
Corrección por tipo de caldera (Fc)	
Caldera de combustión estándar	0,97
Caldera de combustión baja temperatura	1
Caldera de combustión condensación	1,08
Caldera de combustión de biomasa	0,74
Caldera de combustión de biomasa según UNE 300-5	0,95
Corrección por tipología de sistema (Ft)	
Caldera individual	1
Caldera central en bloque	1,075
$\eta_{ESTACIONAL} = \eta_{NOMINAL} \cdot Fc \cdot Ft$	

For example, an individual condensing boiler with a nominal yield of 0.95 (95%) would have an average seasonal yield of: 0.95 • 1.08 • 1 = 1.026 = 102.6%

AVERAGE SEASONAL PERFORMANCE IN BOILERS FOR HEATING AND ACS

RENDIMIENTO ESTACIONAL MEDIO EN CALDERAS para calefacción y ACS	
Corrección por tipo de caldera (Fc)	
Caldera mixta de combustión estándar	0,98
Caldera mixta de combustión baja temperatura	1
Caldera mixta de combustión condensación	1,06
Caldera solo ACS de combustión estandar	0,93
Corrección por tipología de sistema (Ft)	
Caldera individual	1
Caldera central en bloque	1,075
$\eta_{ESTACIONAL} = \eta_{NOMINAL} \cdot Fc \cdot Ft$	

The same individual condensation boiler with nominal yield 0.95 (95%) but also used for ACS, would have an average seasonal yield of: 0.95 • 1.06 • 1 = 1.007 = 100.7%

AVERAGE SEASONAL PERFORMANCE IN EQUIPMENT WITH JOULE EFFECT

RENDIMIENTO ESTACIONAL MEDIO EN EQUIPOS POR EFECTO JOULE	
Factor de corrección (Fc)	
Equipos con regulación automática	1
Equipos con regulación manual	0,97
$\eta_{ESTACIONAL} = \eta_{NOMINAL} \cdot Fc$	

An example: Electric water thermometer NOMINAL 100% with automatic regulation: MEDIUM PERFORMANCE = 1 • 1 = 1 = 100%

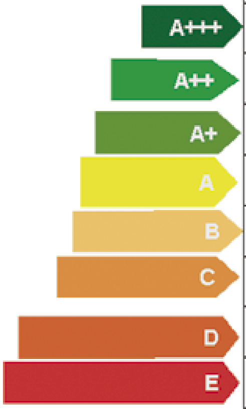
AVERAGE SEASONAL PERFORMANCE IN EQUIPMENT WITH HEAT PUMP

In this case the nominal performance is called

- COP for heat

- EER for cold

At present, the SCOP and the SEER must also be labeled on the machines, which are the seasonal average yields that should be used.



	SEER	SCOP
A+++	SEER ≥ 8,50	SCOP ≥ 5,10
A++	6,10 ≤ SEER < 8,50	4,60 ≤ SCOP < 5,10
A+	5,60 ≤ SEER < 6,10	4,00 ≤ SCOP < 4,60
A	5,10 ≤ SEER < 5,60	3,40 ≤ SCOP < 4,00
B	4,60 ≤ SEER < 5,10	3,10 ≤ SCOP < 3,40
C	4,10 ≤ SEER < 4,60	2,80 ≤ SCOP < 3,10
D	3,60 ≤ SEER < 4,10	2,50 ≤ SCOP < 2,80
E	3,10 ≤ SEER < 3,60	2,20 ≤ SCOP < 2,50
F	2,60 ≤ SEER < 3,10	1,90 ≤ SCOP < 2,20
G	SEER < 2,60	SCOP < 1,90

P4. Calculation of the contribution of renewable energies INITIAL AND FINAL

Assess the energy contribution of renewable energy sources to the demand of the system

For example, if a solar thermal system contributes 30% per CTE, the following calculation would be made:

- Total energy demand: 1000 KWh
- Renewables contribution: 1000 • 0.3 = 300KWh
- Demand for non-renewable energy = 700 KWh

P5. Calculation of INICIAL and FINAL non-renewable primary energy consumption.

Factores de paso de Energía Final			
Energético	**a Energía Primaria Total (kWhEP/kWhEF)**	**a Energía Primaria No Renovable (kWhEPNR/kWhEF)**	**a Emisiones de CO2 (kgCO2/kWhEF)**
Electricidad	2,368	1,954	0,331
Gasoleo calefaccion / Fuel-oil	1,182	1,179	0,311
GLP	1,204	1,201	0,254
Gas Natural	1,195	1,190	0,252
Carbon	1,084	1,082	0,472
Biomasa no densificada	1,037	0,034	0,018
Biomasa densificada (pelets)	1,113	0,085	0,018

Source: Software Herramienta Unificada LIDER CALENER (HULC)

For example, for a room that has a heat requirement of 1000KWh of energy per year and that uses a natural gas boiler with seasonal net yield of 95%, the following calculation would be made:

- USEFUL ENERGY REQUIREMENT: 1000 KWh (IS WHAT IS NEEDED)

- FINAL ENERGY: 1000 / 0.95 = 1052 KWh (IT IS WHAT THE BOILER NEEDS AND WHAT THE USER IS GOING TO PAY As the PCI of natural gas is 11.08KWh / m3, then 1052 / 11.08 = 94.94m3 of natural gas is needed)

- TOTAL PRIMARY ENERGY: 1052 x 1195 = 1257.14 KWh

- NON-RENEWABLE PRIMARY ENERGY: 1052 x 1.19 = 1251.88 KWh

As the PCI of natural gas is 11.08KWh / m3, then 1257.14 / 11.08 = 113.46 m3 of natural gas is needed in origin. The difference with the 94.94m3 (113.46-94.94 = 18.52m3) are losses in transformation and distribution.

CO2 EMISSIONS: 1052 x 0.254 = 267 kgCO2

To make a complete life cycle calculation it would be necessary to carry out the previous steps. They allow to know the global saving in non-renewable primary energy and the CO2 emissions.

But the customer is usually not interested in the complete cycle, but the consumptions that he will have to pay in energy sources (gas, electricity ...)

In this case, the energy saving is that given by the difference in final demands obtained by the following equation, forgetting the coefficients of passage from primary energy to final energy.

$$C\ (Consumo\ de\ energía\ no\ renovable) = \frac{D\ (Demanda\ de\ energía)}{R\ (Rendimiento\ de\ las\ instalaciones)} - EERR$$

If consumption is known because bills are available (electricity, natural gas, biomass ...) then savings can be calculated without the need to calculate demand or performance (we already know consumption).

P6. Evolution of fuel prices.

The cost of fuel is a value that can be consulted by various means, but difficult to harmonize given that it is different according to the marketing company, geographical area or type of contract.

On the other hand, the evolution of these prices is again a factor to be determined if we want to make estimates in the medium or long term (15 to 30 years).

Current prices are known, but futures are more complicated to foresee, and should be estimated, although it depends on many factors:

- Offer and demand
- Political strategy
- International conjuncture

The IDAE publishes a monthly report with fuel prices on this page:

http://www.idae.es/index.php/idpag.802/relcategoria.1368/relmenu.363/mod.pags/mem.detalle

Coste combustible	€/Kwh	% Incremento anual
Electricidad	0,170	6,00%
Gas natural	0,060	5,00%
Gasoil	0,096	5,00%
Fuel-oil	0,102	5,00%
GLP	0,120	5,00%
Carbón	0,130	4,00%
Pellets	0,053	2,50%
Biomasa (otro tipo)	0,380	1,00%
Energías renovables	0,000	0,00%

Fuel costs and estimated annual percentage increase. Own elaboration

P7. Calculation of ECONOMIC SAVINGS between INITIAL and FINAL situation.

At this point it will be necessary to calculate the annual economic savings between the initial (present) and final (future) situations.

It is therefore a question of calculating the amount of fuel needed to satisfy the energy demand in the pre and post-reform conditions.

It must be borne in mind that renewables can have a cost (for example, biomass). On the other hand, the cost of fuel can be 0 as solar thermal or photovoltaic. You have to calculate the fuel expense.

$$\textbf{Cantidad de combustible} = \frac{\textbf{Energía Necesaria}}{\textbf{PCI}}$$

Donde el PCI = Es el poder calorífico inferior del combustible

The amount of fuel needed will be the ratio between the energy demanded and the PCI of the fuel (parameter of each fuel).

The fuel savings will be, therefore:

GASTO PREVIO A LA MEDIDA Gasto en combustible INICIAL = (Cantidad de combustible INICIAL) **x** (Precio del combustible)
GASTO POSTERIOR A LA MEDIDA Gasto en combustible FINAL = (Cantidad de combustible FINAL) x (Precio del combustible)
AHORRO ECONÓMICO: (Gasto en combustible FINAL) - (Gasto en combustible INICIAL)

It is important to keep in mind that there may be facilities that have more than one fuel. For example, gas and electricity, gas and biomass ... in these cases, the total savings will be the sum of the savings of each of the fuels used.

If you intend to make a calculation type NPV or TIR to several years of study will be necessary to make an annual estimate of cash flow so that the annual economic savings will not only be savings in fuel energy but also, for example, cost savings of maintenance, the costs of replacement or replacement of equipment by end of useful life (a parameter that is very important in the case of lighting), the expense in installments of bank loans or any other modification of the initial situation with the future.

P8. Valuation of the investment

It involves budgeting the work to be done in the implementation of the rehabilitation measure.

You need to know:

- Materials and equipment
- Auxiliary means
- Workforce
- Technical assistance

Very important: it is also necessary to assess the future evolution of the maintenance cost of the measure in FUTURE YEARS.

P9. Estimation of the future evolution of important variables in the economic analysis: CPI, discount rates...

If parameters are to be used at present time as the gross amortization period, it is not necessary to evaluate scenarios of the evolution of certain variables in the future.

On the other hand, if we want to make a future viability analysis updated to present, it will be necessary to assume the evolution in trend of the most common indices in economic and financial perspective:

- IPC Fuels: Annual rise in fuel prices ...
- CPI Maintenance: Annual increase in prices for example of labor ...
- Interest rate for possible financing credits for the measure

- Discount rate or opportunity cost: Average remuneration rate of having the money in the bank or in another investment

These parameters are those that will appear in analyzes such as in the NPV or the TIR.

P10. Assessment of the possibility of subsidies, external financing, credits...

As energy efficiency is one of the strategic pillars of the European Union, it is quite usual to be able to have possible government subsidies (state, autonomous or local) for the implementation of energy rehabilitation measures that can reduce the investment cost. Also, if the investment is high, it may require external financing (bank loans ...) that increase the investment cost due to the gradual payment of interest.

Both possibilities must be planned and calculated in advance in order to carry out a more complete and realistic feasibility analysis.

P11. Final economic and viability analysis: Amortization period, NPV, IRR...

At this point, all the sensitive information has been collected in order to carry out a correct economic-financial analysis of the feasibility of the measure to be implemented.

It will be the moment therefore to develop the most habitual indicators that allow knowing the results and times in which the profitability of the implantation of the measure will move.

Among the most prominent are:

- Gross amortization period
- RBG
- Annual gross yield

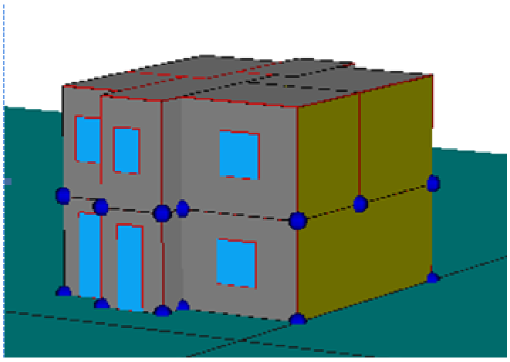
- TRI
- Benefit / Cost Ratio (B / C)
- NPV and IRR - Calculation of the cash flows of each year since the implementation of the measure with the valuation of parameters already mentioned: CPI, credits, subsidies, opportunity cost ...

2. Actions to improve insulation on facades

2. Actions to improve insulation on facades

Next, we intend to carry out a series of simulation exercises of different energy efficiency measures to study their profitability with the indicators already explained.

The purpose of these exercises is to calculate the savings in non-renewable primary energy consumption of some energy efficiency measures in a single-family housing building.



The home has the following types of enclosures at the beginning:

FLAT ROOF

Nº	Material	Espesor	Conductividad	Densidad	Cp
1	Plaqueta o baldosa cerámica	0,020	1,000	2000	800
2	Mortero de áridos ligeros [vermiculita perlita]	0,010	0,410	1000	1000
3	MW Lana mineral [0.04 W/[mK]]	0,120	0,040	40	1000
4	Betún fieltro o lámina	0,003	0,230	1100	1000
5	Mortero de áridos ligeros [vermiculita perlita]	0,010	0,410	1000	1000
6	Hormigón en masa 2000 < d < 2300	0,020	1,650	2150	1000
7	FU Entrevigado de hormigón aligerado -Canto	0,250	1,000	1230	1000
8	Enlucido de yeso 1000 < d < 1300	0,010	0,570	1150	1000

FORGED WITH THE GROUND

Nº	Material	Espesor	Conductividad	Densidad	Cp
1	Azulejo cerámico	0,020	1,300	2300	840
2	EPS Poliestireno Expandido [0.037 W/[mK]]	0,050	0,037	30	1000
3	Mortero de cemento o cal para albañilería y	0,020	0,550	1125	1000
4	Hormigón armado 2300 < d < 2500	0,020	2,300	2400	1000
5	Tierra apisonada adobe bloques de tierra	0,150	1,100	1885	1000

EXTERIOR WALLS

	Material	Espesor	Conductividad	Densidad	Cp
1	1/2 pie LM métrico o catalán 40 mm< G < 50	0,115	1,020	2170	1000
2	Mortero de áridos ligeros [vermiculita perlita]	0,010	0,410	1000	1000
3	EPS Poliestireno Expandido [0.037 W/[mK]]	0,030	0,037	30	1000
4	1 pie LM métrico o catalán 40 mm< G < 50	0,240	1,030	2140	1000
5	Tabique de LH sencillo [40 mm < Espesor <	0,040	0,556	1000	1000
6	Enlucido de yeso 1000 < d < 1300	0,010	0,570	1150	1000

WALLS IN CONTACT WITH THE TERRAIN

Nº	Material	Espesor	Conductividad	Densidad	Cp
1	1/2 pie LM métrico o catalán 40 mm< G < 50	0,115	1,020	2170	1000
2	Mortero de áridos ligeros [vermiculita perlita]	0,010	0,410	1000	1000
3	EPS Poliestireno Expandido [0.037 W/[mK]]	0,060	0,037	30	1000
4	Mortero de áridos ligeros [vermiculita perlita]	0,010	0,410	1000	1000
5	Enlucido de yeso 1000 < d < 1300	0,010	0,570	1150	1000

WINDOWS

Grupo Vidrio	Dobles en posición vertical
Vidrio	VER_DC_4-6-6_g_0.6
Grupo Marco	De Madera en posición vertical
Marco	VER_Madera de densidad media baja
% hueco cubierto por el marco	15,00 ☐ ¿Es una puerta?
Permeabilidad al aire	25,00 m³/hm² a 100 Pa

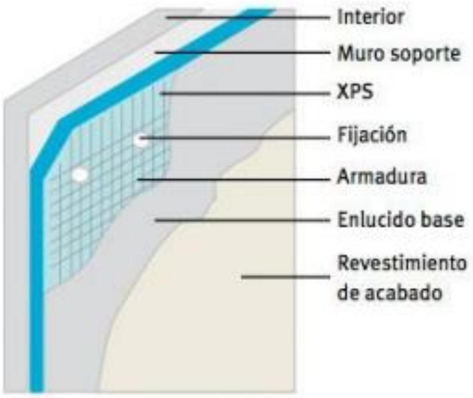
FACILITIES

In this case it is a heating and DHW installation using a 25KW boiler and a heat pump cooling installation (SEER = 2.6) of 4KW cooling.

STEP 1 - Approach of the measure of energy efficiency - IMPROVEMENT OF THE BEHAVIOR OF THE ENVELOPE OF THE FACADE

It is intended to place an insulation system on the outside with extruded polystyrene (XPS) insulation of 40mm respectively and a mortar coating of 20mm on reinforcement.

It is placed in the following way:



Therefore with this system 4 new layers are added to the facade from the outside

- XPS insulation 40mm thick

- Armor

- Base plastering

- Finishing coating

The initial transmittance of the façade is 0.69 W / m2K, while the initial transmittance after the action is 0.37 W / m2K.

This type of measures and other similar action on the facades (SATE systems) reduce heat losses through the envelope, requiring less energy to maintain comfort conditions (reduction in demand).

The exterior insulation of the facades (SATE system) is a very common measure at present in energy rehabilitation since taking advantage of any type of maintenance action on old facades this type of reforms can be proposed.

STEP 2. Calculation of the INITIAL AND FINAL demand of heating and cooling energy

There are many ways to approach the calculation of energy demand. The best option is to simulate the building thermally with a program that calculates the energy demand by time method. In this case, HULC (Unified Tool LIDER-CALENER) will be used, which is the official program recognized by the Ministry of Industry.

Once the building is modeled, the energy demand of the building is calculated through the energy rating button.

The program makes the energy simulation of the 8760 hours of the year and returns the values of energy demand, final energy and primary energy consumption (renewable and non-renewable).

SITUACIÓN DE INICIO	
DEMANDA DE ENERGÍA ÚTIL INICIAL DE LA VIVIENDA	
Demanda útil total de calefacción y ACS (KWh/año)	**8473,52**
Demanda útil total de refrigeración (KWh/año)	**1850,25**

Once the changes in the model corresponding to the measure to be executed have been made, the new useful energy demand values are available:

SITUACIÓN MEJORADA FINAL	
DEMANDA DE ENERGÍA ÚTIL FINAL DE LA VIVIENDA	
Demanda útil total de calefacción y ACS (KWh/año)	**2816,56**
Demanda útil total de refrigeración (KWh/año)	**850,34**

STEP 3. Calculation of the INITIAL and FINAL average seasonal performance of the installation of heat and cold

The calculation of the average seasonal performance of a cold or heat equipment is quite complicated, but it can be approximated as follows:

AVERAGE SEASONAL PERFORMANCE IN BOILERS

RENDIMIENTO ESTACIONAL MEDIO EN CALDERAS	
Corrección por tipo de caldera (Fc)	
Caldera de combustión estándar	0,97
Caldera de combustión baja temperatura	1
Caldera de combustión condensación	1,08
Caldera de combustión de biomasa	0,74
Caldera de combustión de biomasa según UNE 300-5	0,95
Corrección por tipología de sistema (Ft)	
Caldera individual	1
Caldera central en bloque	1,075
$\eta_{ESTACIONAL} = \eta_{NOMINAL} \cdot Fc \cdot Ft$	

AVERAGE SEASONAL PERFORMANCE IN BOILERS FOR HEATING AND ACS

RENDIMIENTO ESTACIONAL MEDIO EN CALDERAS para calefacción y ACS	
Corrección por tipo de caldera (Fc)	
Caldera mixta de combustión estándar	0,98
Caldera mixta de combustión baja temperatura	1
Caldera mixta de combustión condensación	1,06
Caldera solo ACS de combustión estandar	0,93
Corrección por tipología de sistema (Ft)	
Caldera individual	1
Caldera central en bloque	1,075
$\eta_{ESTACIONAL} = \eta_{NOMINAL} \cdot Fc \cdot Ft$	

In the example, an individual boiler of nominal performance standard 0.95, would have an average seasonal yield of: 0.95 • 0.98 • 1 = 0.93 = 93%

AVERAGE SEASONAL PERFORMANCE IN EQUIPMENT WITH HEAT PUMP

Currently, heat pumps are labeled with the SCOP and SEER parameters, which are the seasonal average heat and cold yield respectively.

	SEER	SCOP
A+++	SEER ≥ 8,50	SCOP ≥ 5,10
A++	6,10 ≤ SEER < 8,50	4,60 ≤ SCOP < 5,10
A+	5,60 ≤ SEER < 6,10	4,00 ≤ SCOP < 4,60
A	5,10 ≤ SEER < 5,60	3,40 ≤ SCOP < 4,00
B	4,60 ≤ SEER < 5,10	3,10 ≤ SCOP < 3,40
C	4,10 ≤ SEER < 4,60	2,80 ≤ SCOP < 3,10
D	3,60 ≤ SEER < 4,10	2,50 ≤ SCOP < 2,80
E	3,10 ≤ SEER < 3,60	2,20 ≤ SCOP < 2,50
F	2,60 ≤ SEER < 3,10	1,90 ≤ SCOP < 2,20
G	SEER < 2,60	SCOP < 1,90

In the example, the installation has a 4KW heat pump for cooling (heating is done with the boiler) with a SEER of 2.6 = 260%

RENDIMIENTO ESTACIONAL MEDIO INSTALACIONES	
Rendimiento estacional medio CALDERA	93%
Rendimiento estacional medio BOMBA DE CALOR	260%

The returns of the improved situation are the same since they are not acted on.

STEP 4. Calculation of the contribution of renewable energies INITIAL AND FINAL

Assess the energy contribution of renewable energy sources to the demand of the system.

In the example there are no renewable energy contributions either in the initial situation or in the final situation.

STEP 5. Calculation of INITIAL and FINAL energy consumption.

$$C\ (Consumodeenergíanorenovable) = \frac{D\ (Demandadeenergía)}{R\ (Rendimientodelasinstalaciones)} - EERR$$

The data on the demand for useful energy, the performance of the facilities and the contribution of renewable energy are available.

To make the global calculation of the energy efficiency measure, the correct thing would be to compare the energy saving from its origin from the consumption of non-renewable primary energy. This information is not only much more accurate, but also allows quantifying the savings in CO2 emissions of the system.

On the other hand, for conventional customers, savings at the source are not important and it will only be necessary to study the savings in final energy ... that is, the one that is actually invoiced by the customer.

If consumption is known because bills are available (electricity, natural gas, biomass ...), then savings can be calculated without the need for calculation of demand or performance (we already know consumption).

For example, housing that requires 8473 KWh / year of heat and that uses a natural gas boiler with a net seasonal yield of 93% would be:

- USEFUL ENERGY REQUIREMENT: 8473 KWh (IS WHAT IS NEEDED)
- FINAL ENERGY: 8473 / 0.93 = 9110 KWh (IT IS WHAT THE BOILER NEEDS AND WHAT THE USER IS GOING TO PAY As the PCI of natural gas is 11.08KWh / m3, then 9110 / 11.08 = 822 m3 of natural gas are needed)

This is the necessary energy that the customer actually bills, but to make the calculation more exhaustive, the total primary energy would have to be calculated. To do this, the step coefficients are used, for example, from the Unified Tool LIDER CALENER (HULC) where:

Factores de paso de Energía Final			
Energético	**a Energía Primaria Total (kWhEP/kWhEF)**	**a Energía Primaria No Renovable (kWhEPNR/kWhEF)**	**a Emisiones de CO2 (kgCO2/kWhEF)**
Electricidad	2,368	1,954	0,331
Gasoleo calefaccion / Fuel-oil	1,182	1,179	0,311
GLP	1,204	1,201	0,254
Gas Natural	1,195	1,190	0,252
Carbon	1,084	1,082	0,472
Biomasa no densificada	1,037	0,034	0,018
Biomasa densificada (pelets)	1,113	0,085	0,018

Table extracted from the unified tool LIDER-CALENER

- TOTAL PRIMARY ENERGY: 9110 x 1.195 = 10886 KWh
- NON-RENEWABLE PRIMARY ENERGY: 9110 x 1.19 = 10840 KWh

As the PCI of natural gas is 11.08KWh / m3, then 10886 / 11.08 = 982 m3 of natural gas is needed at origin. The difference of the final energy (822) with the primary energy (982) that gives a result of 160 m3 are losses in transformation and distribution that obviously do not interest the final customer. On the other hand, the contribution of savings in CO2 emissions based on environmental awareness can be interesting.

- CO2 EMISSIONS: 10886 x 0.254 = 2721 kgCO2

For the cooling demand of 420 KWh / year of cold using the 260% net seasonal heat pump, it is obtained by calculating:

- USEFUL ENERGY REQUIREMENT: 1850 KWh (IS WHAT IS NEEDED)

- FINAL ENERGY: 1850 / 2.60 = 711 KWh (IT IS WHAT YOU NEED THE HEAT PUMP IN ELECTRICITY AND WHAT THE USER WILL PAY)

SITUACIÓN DE INICIO	
DEMANDA DE ENERGÍA ÚTIL INICIAL DE LA VIVIENDA	
Demanda útil total de calefacción y ACS (KWh/año)	**8473,52**
Demanda útil total de refrigeración (KWh/año)	**1850,25**
RENDIMIENTO ESTACIONAL MEDIO INSTALACIONES	
Rendimiento estacional medio CALDERA de GAS NATURAL	**93%**
Rendimiento estacional medio BOMBA DE CALOR ELECTRICA	**260%**
DEMANDA DE ENERGÍA FINAL INICIAL DE LA VIVIENDA	
Demanda final de calefacción y ACS EN GAS NATURAL (KWh/año)	**9111,31**
Demanda final total de refrigeración en ELECTRICIDAD (KWh/año)	**711,63**

By performing the same steps with the values of the improved situation you get:

SITUACIÓN MEJORADA FINAL	
DEMANDA DE ENERGÍA ÚTIL FINAL DE LA VIVIENDA	
Demanda útil total de calefacción y ACS (KWh/año)	2816,56
Demanda útil total de refrigeración (KWh/año)	850,34
RENDIMIENTO ESTACIONAL MEDIO INSTALACIONES	
Rendimiento estacional medio CALDERA de GAS NATURAL	93%
Rendimiento estacional medio BOMBA DE CALOR ELECTRICA	260%
DEMANDA DE ENERGÍA FINAL DE LA VIVIENDA	
Demanda final de calefacción y ACS EN GAS NATURAL (KWh/año)	3028,56
Demanda final total de refrigeración en ELECTRICIDAD (KWh/año)	327,05

STEP 6. Evolution of fuel prices.

The table exposed in the previous topic will be used

Coste combustible	€/Kwh	% Incremento anual
Electricidad	0,170	6,00%
Gas natural	0,060	5,00%
Gasoil	0,096	5,00%
Fuel-oil	0,102	5,00%
GLP	0,120	5,00%
Carbón	0,130	4,00%
Pellets	0,053	2,50%
Biomasa (otro tipo)	0,380	1,00%
Energías renovables	0,000	0,00%

Fuel costs and estimated annual percentage increase. Own elaboration

STEP 7. Calculation of ECONOMIC SAVINGS between INITIAL and FINAL situation.

At this point it will be necessary to calculate the annual economic savings between the initial (present) and final (future) situations with fuel consumption.

The fuel savings will be, therefore:

GASTO PREVIO A LA MEDIDA Gasto en combustible INICIAL = (Cantidad de combustible INICIAL) **x** (Precio del combustible)
GASTO POSTERIOR A LA MEDIDA Gasto en combustible FINAL = (Cantidad de combustible FINAL) x (Precio del combustible)
AHORRO ECONÓMICO: (Gasto en combustible FINAL) - (Gasto en combustible INICIAL)

It is important to keep in mind that there may be facilities that have more than one fuel. For example, gas and electricity, gas and biomass ... in these cases, the total savings will be the sum of the savings of each of the fuels used.

PRECIO DE LOS COMBUSTIBLES A TIEMPO PRESENTE	
Gas Natural (€/KWh)	0,06
Electricidad (€/KWh)	0,17
COSTE EN COMBUSTIBLE INICIAL	
Coste en GAS NATURAL para calefacción y ACS	546,68 €
Coste en ELECTRICIDAD para refrigeración	120,98 €
TOTAL COSTE EN COMBUSTIBLE INICIAL	**667,66 €**

PRECIO DE LOS COMBUSTIBLES A TIEMPO PRESENTE	
Gas Natural (€/KWh)	0,06
Electricidad (€/KWh)	0,17
COSTE EN COMBUSTIBLE FINAL	
Coste en GAS NATURAL para calefacción y ACS	181,71 €
Coste en ELECTRICIDAD para refrigeración	55,60 €
TOTAL COSTE EN COMBUSTIBLE FINAL	**237,31 €**
AHORRO ECONÓMICO EN LA SITUACIÓN MEJORADA AL AÑO 0	**430,34 €**

If you intend to do a NPV or IRR calculation for several years of study, you will need to make an annual estimate of cash flow so that the annual economic savings will not only be savings in energy fuel but also, for example, savings in energy, maintenance costs, spending on bank loan installments or any other modification of the initial situation with the future.

STEP 8. Valuation of the investment: EQUIPMENT, MATERIALS, LABOR...

The costs per m^2 of placement of the new facade insulation system installed from the outside are the following:

INVERSIÓN INICIAL		
MANO DE OBRA Coste colocación €/m2	16,38	€/m2
COSTE DE MATERIAL Coste del aislante €/m2	11,57	€/m2
MEDIOS AUXILIARES Andamios €/m2	4	€/m2
COSTES INDIRECTOS Proyectos, tasas €/m2	8,56	€/m2
Superficie a instalar	90	m2
TOTAL INVERSION	3.645,90 €	I

STEP 9. Estimation of the future evolution of important variables in the economic analysis: CPI, interest rates...

It also assumes a 5% average increase in energy prices, 2% of the CPI and a 3% discount rate.

STEP 10. Assessment of the possibility of subsidies, external financing, credits...

The need for external financing or subsidies is not considered in this case. It will be done with own funds.

STEP 11. Final economic and viability analysis: Amortization period, NPV, IR...

You already have all the necessary data for the calculation of the different indicators that have been raised.

Some present time as the gross amortization period, RGB, TRI... and others in future time such as the NPV, the IRR or the B / C ratio.

<u>Calculation of the present time indicators:</u>

INDICADORES A TIEMPO PRESENTE		
AHORRO ECONÓMICO EN LA SITUACIÓN MEJORADA AL AÑO 0	430,34 €	A
Vida útil de la medida (años)	25	VU
Ahorro total neto (A·VU)	10.758,60 €	AN
Inversión total (equipos, mano obra...) (€)	3.645,90 €	I
Periodo de amortización bruta (años)	8,47	PB
Rendimiento bruto de la inversión (%)	195%	RGB
Rendimiento bruto anual de la inversión (%) (RGB/VU)	8%	RBA
Depreciación anual de la inversión (€)	145,84 €	D
Año de estudio	10	AE
Ahorro total neto año de estudio (A·AE)	4.303,44 €	ANE
Tasa de retorno de la inversión (TRI) (%)	78%	TRI

In the table you can see the most important obtained values that allow to determine the profitability at the present time of the performance:

- Gross amortization period: 8.47 years over 25 useful life.

- RBA: annual yield of 8% on a total RGB of 195% in the useful life of 25 years.

- Internal rate of return of 78% for the year of study 10 over the useful life of 25 years.

It is therefore an easily amortizable investment.

<u>Calculation of future time indicators:</u>

In this case, the two most common indicators are presented, such as the NPV and the IRR. For its calculation, the forecast of future evolution of some parameters is needed, such as a 5% average increase in energy prices, 2% of the CPI and a 3% discount rate. At the same time, future annual maintenance costs of € 60 / year (which in the initial situation do not exist) are expected. Developing the equations of annual cash flows provides that:

Inversión inicial	3.645,90 €
Ahorro económico anual	430,34 €
Costes de mantenimiento anuales	60,00
Incremento de los precios de la energía:	5,00%
Tasa de inflación prevista (IPC):	2,00%
Tasa de descuento - Coste de oportunidad:	3,00%
Tipo de interés bancario	5%

AISLAMIENTO XPS 4CM

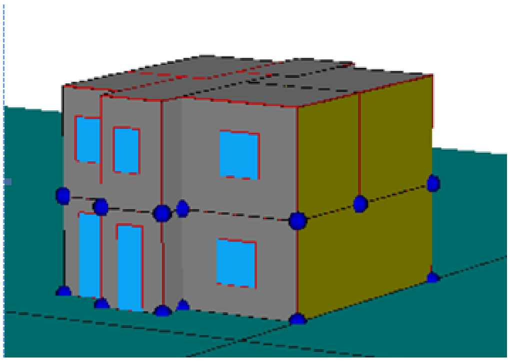
Plazo (años)	Ingresos - Ahorros	Gastos - Costes	Flujo de caja	VAN al año en curso	TIR año en curso
Inversión inicial - Año 0	- €	3.645,90 €	-3.645,90 €		
Año 1	451,86 €	61,20 €	390,66 €	-3.266,62	#¡NUM!
Año 2	474,45 €	62,42 €	412,03 €	-2.878,24	#¡NUM!
Año 3	498,18 €	63,67 €	434,50 €	-2.480,61	#¡NUM!
Año 4	523,09 €	64,95 €	458,14 €	-2.073,56	-24%
Año 5	549,24 €	66,24 €	483,00 €	-1.656,92	-15%
Año 6	576,70 €	67,57 €	509,13 €	-1.230,53	-8%
Año 7	605,54 €	68,92 €	536,62 €	-794,21	-3%
Año 8	635,81 €	70,30 €	565,51 €	-347,79	1%
Año 9	667,60 €	71,71 €	595,90 €	108,92	4%
Año 10	700,98 €	73,14 €	627,85 €	576,09	6%
Año 11	736,03 €	74,60 €	661,43 €	1.053,93	7%
Año 12	772,84 €	76,09 €	696,74 €	1.542,61	9%
Año 13	811,48 €	77,62 €	733,86 €	2.042,33	10%
Año 14	852,05 €	79,17 €	772,88 €	2.553,30	11%
Año 15	894,65 €	80,75 €	813,90 €	3.075,71	12%
Año 16	939,39 €	82,37 €	857,02 €	3.609,78	12%
Año 17	986,36 €	84,01 €	902,34 €	4.155,71	13%
Año 18	1.035,67 €	85,69 €	949,98 €	4.713,72	13%
Año 19	1.087,46 €	87,41 €	1.000,05 €	5.284,03	13%
Año 20	1.141,83 €	89,16 €	1.052,67 €	5.866,87	14%
Año 21	1.198,92 €	90,94 €	1.107,98 €	6.462,47	14%
Año 22	1.258,87 €	92,76 €	1.166,11 €	7.071,05	14%
Año 23	1.321,81 €	94,61 €	1.227,20 €	7.692,86	15%
Año 24	1.387,90 €	96,51 €	1.291,40 €	8.328,14	15%
Año 25	1.457,30 €	98,44 €	1.358,86 €	8.977,14	15%

In this case, the NPV becomes positive in year 9 (the amortization period was 8.47 years). The IRR is 15% at the end of the useful life (well above the 3% desired as the discount rate or opportunity cost).

The action through thermal insulation of facades is one of the most profitable today. In addition, there are many neighborhood communities that consider the measure due to the poor state of maintenance of the facades simply derived from the passage of time. In these cases, it is quite simple to be able to propose this type of rehabilitation measures since it allows the aesthetic improvement of the facade that is also amortized in the medium term.

3. Improvements in window insulation

It starts from the basis of the previous example, a single-family housing building.

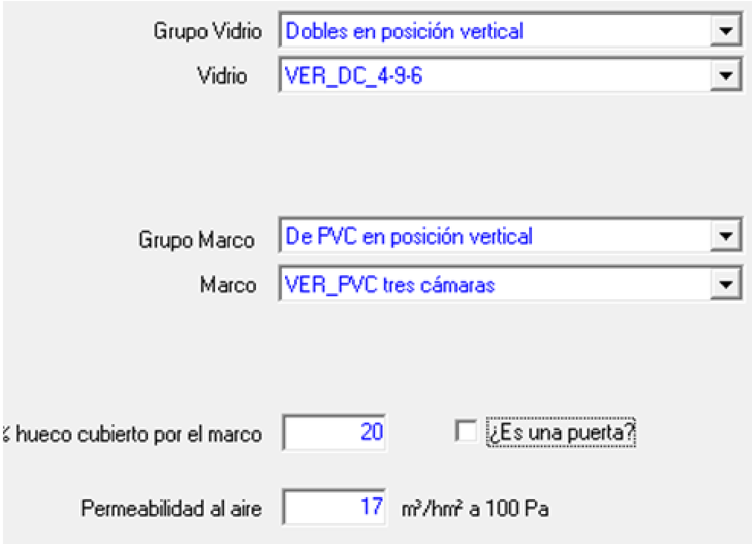


STEP 1 - Approach of the energy efficiency measure - IMPROVEMENT OF THE WINDOWS INSULATION

It is intended to replace the current windows with others with lower energy losses.

These new windows have the following properties: PVC frame and double glass 4-9-6.

Currently, windows with thermal bridge break and double glass with PVC frame are an effective alternative to reduce the energy cost of a home. Especially if the existing windows are of low quality: simple glass, old frames of wood or aluminum without thermal break...



STEP 2. Calculation of the INITIAL AND FINAL demand of heating and cooling energy

The starting point is the same as in the previous example. That is to say:

SITUACIÓN DE INICIO	
DEMANDA DE ENERGÍA ÚTIL INICIAL DE LA VIVIENDA	
Demanda útil total de calefacción y ACS (KWh/año)	**8473,52**
Demanda útil total de refrigeración (KWh/año)	**1850,25**

Once the changes in the model corresponding to the measure to be executed have been made, the new useful energy demand values are available:

SITUACIÓN MEJORADA FINAL	
DEMANDA DE ENERGÍA ÚTIL FINAL DE LA VIVIENDA	
Demanda útil total de calefacción y ACS (KWh/año)	**6439,23**
Demanda útil total de refrigeración (KWh/año)	**681,45**

STEP 3. Calculation of the INITIAL and FINAL average seasonal performance of the installation of heat and cold

In the example, the installation has a 4KW heat pump for cooling (heating is done with the boiler) with a SEER of 2.6 = 260%

RENDIMIENTO ESTACIONAL MEDIO INSTALACIONES	
Rendimiento estacional medio CALDERA	93%
Rendimiento estacional medio BOMBA DE CALOR	260%

The returns of the improved situation are the same since they are not acted on.

STEP 4. Calculation of the contribution of renewable energies INITIAL AND FINAL

Assess the energy contribution of renewable energy sources to the demand of the system.

In the example there are no renewable energy contributions either in the initial situation or in the final situation.

STEP 5. Calculation of INITIAL and FINAL energy consumption.

The data on the demand for useful energy, the performance of the facilities and the contribution of renewable energy are available. The calculation of the final energy demand is made for the initial and final situations.

SITUACIÓN DE INICIO	
DEMANDA DE ENERGÍA ÚTIL INICIAL DE LA VIVIENDA	
Demanda útil total de calefacción y ACS (KWh/año)	**8473,52**
Demanda útil total de refrigeración (KWh/año)	**1850,25**
RENDIMIENTO ESTACIONAL MEDIO INSTALACIONES	
Rendimiento estacional medio CALDERA de GAS NATURAL	**93%**
Rendimiento estacional medio BOMBA DE CALOR ELECTRICA	**260%**
DEMANDA DE ENERGÍA FINAL INICIAL DE LA VIVIENDA	
Demanda final de calefacción y ACS EN GAS NATURAL (KWh/año)	**9111,31**
Demanda final total de refrigeración en ELECTRICIDAD (KWh/año)	**711,63**

By performing the same steps with the values of the improved situation you get:

SITUACIÓN MEJORADA FINAL	
DEMANDA DE ENERGÍA ÚTIL FINAL DE LA VIVIENDA	
Demanda útil total de calefacción y ACS (KWh/año)	**6439,23**
Demanda útil total de refrigeración (KWh/año)	**681,45**
RENDIMIENTO ESTACIONAL MEDIO INSTALACIONES	
Rendimiento estacional medio CALDERA de GAS NATURAL	**93%**
Rendimiento estacional medio BOMBA DE CALOR ELECTRICA	**260%**
DEMANDA DE ENERGÍA FINAL DE LA VIVIENDA	
Demanda final de calefacción y ACS EN GAS NATURAL (KWh/año)	**6923,90**
Demanda final total de refrigeración en ELECTRICIDAD (KWh/año)	**262,10**

STEP 6. Evolution of fuel prices.

The table exposed in the previous topic will be used

Coste combustible	€/Kwh	% Incremento anual
Electricidad	0,170	6,00%
Gas natural	0,060	5,00%
Gasoil	0,096	5,00%
Fuel-oil	0,102	5,00%
GLP	0,120	5,00%
Carbón	0,130	4,00%
Pellets	0,053	2,50%
Biomasa (otro tipo)	0,380	1,00%
Energías renovables	0,000	0,00%

Fuel costs and estimated annual percentage increase. Own elaboration

STEP 7. Calculation of ECONOMIC SAVINGS between INITIAL and FINAL situation.

At this point it will be necessary to calculate the annual economic savings between the initial (present) and final (future) situations with fuel consumption.

The fuel savings will be, therefore:

GASTO PREVIO A LA MEDIDA Gasto en combustible INICIAL = (Cantidad de combustible INICIAL) **x** (Precio del combustible)
GASTO POSTERIOR A LA MEDIDA Gasto en combustible FINAL = (Cantidad de combustible FINAL) x (Precio del combustible)
AHORRO ECONÓMICO: (Gasto en combustible FINAL) - (Gasto en combustible INICIAL)

It is important to keep in mind that there may be facilities that have more than one fuel. For example, gas and electricity, gas and biomass... in these cases the total savings will be the sum of the savings of each of the fuels used.

PRECIO DE LOS COMBUSTIBLES A TIEMPO PRESENTE	
Gas Natural (€/KWh)	**0,06**
Electricidad (€/KWh)	**0,17**
COSTE EN COMBUSTIBLE INICIAL	
Coste en GAS NATURAL para calefacción y ACS	**546,68 €**
Coste en ELECTRICIDAD para refrigeración	**120,98 €**
TOTAL COSTE EN COMBUSTIBLE INICIAL	**667,66 €**

PRECIO DE LOS COMBUSTIBLES A TIEMPO PRESENTE	
Gas Natural (€/KWh)	**0,06**
Electricidad (€/KWh)	**0,17**
COSTE EN COMBUSTIBLE FINAL	
Coste en GAS NATURAL para calefacción y ACS	**415,43 €**
Coste en ELECTRICIDAD para refrigeración	**44,56 €**
TOTAL COSTE EN COMBUSTIBLE FINAL	**459,99 €**
AHORRO ECONÓMICO EN LA SITUACIÓN MEJORADA AL AÑO 0	**207,67 €**

If you intend to do a NPV or IRR calculation for several years of study, you will need to make an annual estimate of cash flow so that the annual economic savings will not only be savings in energy fuel but also, for example, savings in energy, maintenance costs, spending on bank loan installments or any other modification of the initial situation with the future.

STEP 8. Valuation of the investment: EQUIPMENT, MATERIALS, LABOR...

The investment to be made with the new configuration consists simply in the replacement of the windows by other better ones is the following:

INVERSIÓN INICIAL		
MANO DE OBRA Coste de la instalación	30	€/ud
COSTE DE MATERIAL Coste de la nueva ventana	300	€/ud
MEDIOS AUXILIARES Andamios €/m2	0	€/ud
COSTES INDIRECTOS Proyectos, tasas €/m2	0	€/ud
Ventanas a instalar	8	ud
TOTAL INVERSION	2.640,00 €	I

STEP 9. Estimation of the future evolution of important variables in the economic analysis: CPI, interest rates...

It also assumes a 5% average increase in energy prices, 2% of the CPI and a 3% discount rate.

STEP 10. Assessment of the possibility of subsidies, external financing, credits...

The need for external financing or subsidies is not considered in this case. It will be done with own funds

STEP 11. Final economic and viability analysis: Amortization period, NPV, IRR...

You already have all the necessary data for the calculation of the different indicators that have been raised.

Some present time as the gross amortization period, RGB, TRI ... and others in future time such as the NPV, the IRR or the B / C ratio.

<u>Calculation of the present time indicators:</u>

INDICADORES A TIEMPO PRESENTE		
AHORRO ECONÓMICO EN LA SITUACIÓN MEJORADA AL AÑO 0	207,67 €	A
Vida útil de la medida (años)	25	VU
Ahorro total neto (A·VU)	5.191,65 €	AN
Inversión total (equipos, mano obra...) (€)	2.640,00 €	I
Periodo de amortización bruta (años)	12,71	PB
Rendimiento bruto de la inversión (%)	97%	RGB
Rendimiento bruto anual de la inversión (%) (RGB/VU)	4%	RBA
Depreciación anual de la inversión (€)	105,60 €	D
Año de estudio	10	AE
Ahorro total neto año de estudio (A·AE)	2.076,66 €	ANE
Tasa de retorno de la inversión (TRI) (%)	39%	TRI

In the table you can see the most important results obtained for this mean at present time:

- Gross amortization period: 12.71 years over 25 useful life.

- RBA: yield of 4% per year on a total RGB of 97% in the useful life of 25 years.

- Internal rate of return of 39% for the year of study 10 over the useful life of 25 years.

It is therefore a profitable investment, although it requires a long amortization period.

<u>Calculation of future time indicators:</u>

In this case, the two most common indicators are presented, such as the NPV and the IRR. For its calculation, the forecast of future evolution of some parameters is needed, such as a 5% average increase in energy prices, 2% of the CPI and a 3% discount rate.

Developing the equations of annual cash flows provides that:

In this case, the NPV becomes positive in year 12 (the amortization period was 12.71 years).

The IRR is 11% at the end of the useful life (well above the 3% desired as the discount rate or opportunity cost).

Inversión inicial	2.640,00 €
Ahorro económico anual	207,67 €
Costes de mantenimiento anuales	0,00
Incremento de los precios de la energía:	5,00%
Tasa de inflación prevista (IPC):	2,00%
Tasa de descuento - Coste de oportunidad:	3,00%
Tipo de interés bancario	5%

SUSTITUCIÓN DE VENTANAS

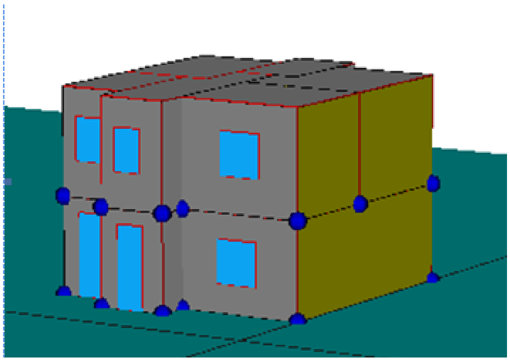
Plazo (años)	Ingresos - Ahorros	Gastos - Costes	Flujo de caja	VAN al año en curso	TIR año en curso
Inversión inicial - Año 0	- €	2.640,00 €	-2.640,00 €		
Año 1	218,05 €	0,00 €	218,05 €	-2.428,30	#¡NUM!
Año 2	228,95 €	0,00 €	228,95 €	-2.212,49	#¡NUM!
Año 3	240,40 €	0,00 €	240,40 €	-1.992,49	#¡NUM!
Año 4	252,42 €	0,00 €	252,42 €	-1.768,22	#¡NUM!
Año 5	265,04 €	0,00 €	265,04 €	-1.539,60	-21%
Año 6	278,29 €	0,00 €	278,29 €	-1.306,53	-14%
Año 7	292,21 €	0,00 €	292,21 €	-1.068,94	-9%
Año 8	306,82 €	0,00 €	306,82 €	-826,73	-5%
Año 9	322,16 €	0,00 €	322,16 €	-579,83	-2%
Año 10	338,27 €	0,00 €	338,27 €	-328,13	1%
Año 11	355,18 €	0,00 €	355,18 €	-71,54	3%
Año 12	372,94 €	0,00 €	372,94 €	190,04	4%
Año 13	391,59 €	0,00 €	391,59 €	456,69	5%
Año 14	411,16 €	0,00 €	411,16 €	728,51	6%
Año 15	431,72 €	0,00 €	431,72 €	1.005,62	7%
Año 16	453,31 €	0,00 €	453,31 €	1.288,11	8%
Año 17	475,97 €	0,00 €	475,97 €	1.576,08	9%
Año 18	499,77 €	0,00 €	499,77 €	1.869,64	9%
Año 19	524,76 €	0,00 €	524,76 €	2.168,91	10%
Año 20	551,00 €	0,00 €	551,00 €	2.473,98	10%
Año 21	578,55 €	0,00 €	578,55 €	2.784,98	10%
Año 22	607,48 €	0,00 €	607,48 €	3.102,02	11%
Año 23	637,85 €	0,00 €	637,85 €	3.425,21	11%
Año 24	669,74 €	0,00 €	669,74 €	3.754,68	11%
Año 25	703,23 €	0,00 €	703,23 €	4.090,55	11%

It treats as it can be observed of a measure with a time of average return of investment (10-12 years). The useful life of the windows is usually much higher, so it is considered a very profitable operation. Everything depends on the quality of the previous windows but in clear cases (simple glass, wood or aluminum frames without breakage of thermal bridges and poor insulation ...) this solution is perfect to reduce the energy bill of a home.

In full promotions the measure is equally effective although it is always more complicated to convince the entire community of the integral change of windows, not so much for the savings obtained but for the diversity of aesthetic criteria of the neighbors. At an individual level, the measure in this case is easier to implement.

4. Actions in improvement of roof insulation

It starts from the basis of the previous example, a single-family housing building.

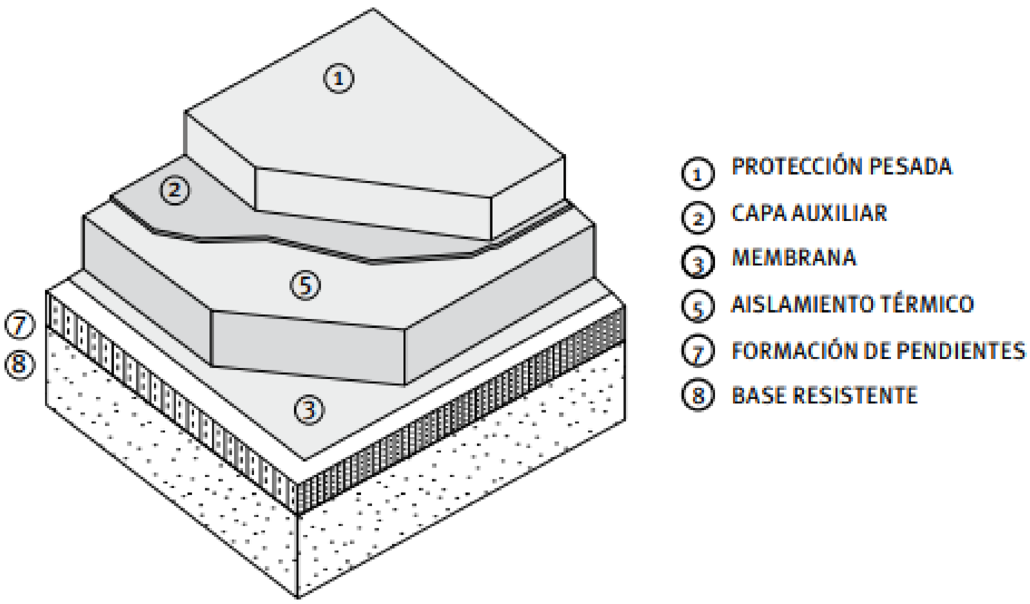


STEP 1 - Approach of the energy efficiency measure - IMPROVEMENT OF THE INSULATION IN THE COVERINGS

In the traditional flat roof, the waterproofing sheet is exposed to harsh working conditions, in our country especially at high temperatures, which generally causes its deterioration over time and finally its failure. It is intended to improve the roof with an EPS-h insulation system that protects the waterproofing sheet from changes in temperature and continuous deterioration due to weather effects.

As it is a walkable roof, the finish is usually with stone elements placed on elevators, so that the roof remains ventilated.

The new configuration added to the current one is the following:



As in the case of facade insulation, the improvement of the insulation of the roof is based on the principle of reducing the thermal transmittance of the roof enclosure. By reducing its transmittance (in this case it is reduced from 0.45 W / m2K to 0.28 W / m2K), energy losses are minimized by this part of the envelope and the energy demand needed by the building to maintain the comfort conditions.

It is a measure that can be raised whenever any type of roof reform is going to be carried out, even if it is simply for maintenance.

STEP 2. Calculation of the INITIAL AND FINAL demand of heating and cooling energy

The starting point is the same as in the previous example. That is to say:

SITUACIÓN DE INICIO	
DEMANDA DE ENERGÍA ÚTIL INICIAL DE LA VIVIENDA	
Demanda útil total de calefacción y ACS (KWh/año)	8473,52
Demanda útil total de refrigeración (KWh/año)	1850,25

Once the changes in the model corresponding to the measure to be executed have been made, the new useful energy demand values are available:

SITUACIÓN MEJORADA FINAL	
DEMANDA DE ENERGÍA ÚTIL FINAL DE LA VIVIENDA	
Demanda útil total de calefacción y ACS (KWh/año)	5507,45
Demanda útil total de refrigeración (KWh/año)	1202,5

STEP 3. Calculation of the INITIAL and FINAL average seasonal performance of the installation of heat and cold

In the example, the installation has a 4KW heat pump for cooling (heating is done with the boiler) with a SEER of 2.6 = 260%

RENDIMIENTO ESTACIONAL MEDIO INSTALACIONES	
Rendimiento estacional medio CALDERA	93%
Rendimiento estacional medio BOMBA DE CALOR	260%

The returns of the improved situation are the same since they are not acted on.

STEP 4. Calculation of the contribution of renewable energies INITIAL AND FINAL

Assess the energy contribution of renewable energy sources to the demand of the system.

No renewable energy is contributed to the system.

STEP 5. Calculation of INITIAL and FINAL energy consumption.

The data on the demand for useful energy, the performance of the facilities and the contribution of renewable energy are available. The calculation of the final energy demand is made for the initial and final situations.

SITUACIÓN DE INICIO	
DEMANDA DE ENERGÍA ÚTIL INICIAL DE LA VIVIENDA	
Demanda útil total de calefacción y ACS (KWh/año)	**8473,52**
Demanda útil total de refrigeración (KWh/año)	**1850,25**
RENDIMIENTO ESTACIONAL MEDIO INSTALACIONES	
Rendimiento estacional medio CALDERA de GAS NATURAL	**93%**
Rendimiento estacional medio BOMBA DE CALOR ELECTRICA	**260%**
DEMANDA DE ENERGÍA FINAL INICIAL DE LA VIVIENDA	
Demanda final de calefacción y ACS EN GAS NATURAL (KWh/año)	**9111,31**
Demanda final total de refrigeración en ELECTRICIDAD (KWh/año)	**711,63**

By performing the same steps with the values of the improved situation you get:

SITUACIÓN MEJORADA FINAL	
DEMANDA DE ENERGÍA ÚTIL FINAL DE LA VIVIENDA	
Demanda útil total de calefacción y ACS (KWh/año)	**5507,45**
Demanda útil total de refrigeración (KWh/año)	**1202,5**
RENDIMIENTO ESTACIONAL MEDIO INSTALACIONES	
Rendimiento estacional medio CALDERA de GAS NATURAL	**93%**
Rendimiento estacional medio BOMBA DE CALOR ELECTRICA	**260%**
DEMANDA DE ENERGÍA FINAL DE LA VIVIENDA	
Demanda final de calefacción y ACS EN GAS NATURAL (KWh/año)	**5921,99**
Demanda final total de refrigeración en ELECTRICIDAD (KWh/año)	**462,50**

STEP 6. Evolution of fuel prices.

The table exposed in the previous topic will be used

Coste combustible	€/Kwh	% Incremento anual
Electricidad	0,170	6,00%
Gas natural	0,060	5,00%
Gasoil	0,096	5,00%
Fuel-oil	0,102	5,00%
GLP	0,120	5,00%
Carbón	0,130	4,00%
Pellets	0,053	2,50%
Biomasa (otro tipo)	0,380	1,00%
Energías renovables	0,000	0,00%

Fuel costs and estimated annual percentage increase. Own elaboration

STEP 7. Calculation of ECONOMIC SAVINGS between INITIAL and FINAL situation.

At this point it will be necessary to calculate the annual economic savings between the initial (present) and final (future) situations with fuel consumption.

The fuel savings will be, therefore:

GASTO PREVIO A LA MEDIDA Gasto en combustible INICIAL = (Cantidad de combustible INICIAL) **x** (Precio del combustible)
GASTO POSTERIOR A LA MEDIDA Gasto en combustible FINAL = (Cantidad de combustible FINAL) x (Precio del combustible)
AHORRO ECONÓMICO: (Gasto en combustible FINAL) - (Gasto en combustible INICIAL)

It is important to keep in mind that there may be facilities that have more than one fuel. For example, gas and electricity, gas and biomass... in these cases, the total savings will be the sum of the savings of each of the fuels used.

PRECIO DE LOS COMBUSTIBLES A TIEMPO PRESENTE	
Gas Natural (€/KWh)	**0,06**
Electricidad (€/KWh)	**0,17**
COSTE EN COMBUSTIBLE INICIAL	
Coste en GAS NATURAL para calefacción y ACS	**546,68 €**
Coste en ELECTRICIDAD para refrigeración	**120,98 €**
TOTAL COSTE EN COMBUSTIBLE INICIAL	**667,66 €**

PRECIO DE LOS COMBUSTIBLES A TIEMPO PRESENTE	
Gas Natural (€/KWh)	0,06
Electricidad (€/KWh)	0,17
COSTE EN COMBUSTIBLE FINAL	
Coste en GAS NATURAL para calefacción y ACS	355,32 €
Coste en ELECTRICIDAD para refrigeración	78,63 €
TOTAL COSTE EN COMBUSTIBLE FINAL	**433,94 €**
AHORRO ECONÓMICO EN LA SITUACIÓN MEJORADA AL AÑO 0	**233,71 €**

If you intend to make a calculation type NPV or TIR to several years of study will be necessary to make an annual estimate of cash flow so that the annual economic savings will not only be savings in fuel energy but also, for example, cost savings of maintenance, the expense in installments of bank loans or any other modification of the initial situation with the future.

STEP 8. Valuation of the investment: EQUIPMENT, MATERIALS, LABOR...

The investment to be made with the new configuration for a 90m2 roof is as follows:

INVERSIÓN INICIAL	
MANO DE OBRA Coste colocación €/m2	**5**
COSTE DE MATERIAL Coste del aislante €/m2	**25**
MEDIOS AUXILIARES Andamios €/m2	**5**
COSTES INDIRECTOS Proyectos, tasas €/m2	**2**
Superficie de aislamiento de cubierta	**90**
TOTAL INVERSION	**3.330,00 €**

STEP 9. Estimation of the future evolution of important variables in the economic analysis: CPI, interest rates...

It also assumes a 5% average increase in energy prices, 2% of the CPI and a 3% discount rate.

STEP 10. Assessment of the possibility of subsidies, external financing, credits...

The need for external financing or subsidies is not considered in this case. It will be done with own funds.

STEP 11. Final economic and viability analysis: Amortization period, NPV, IRR...

You already have all the necessary data for the calculation of the different indicators that have been raised.

Some present time as the gross amortization period, RGB, TRI ... and others in future time such as the NPV, the IRR or the B / C ratio.

<u>Calculation of the present time indicators:</u>

INDICADORES A TIEMPO PRESENTE	
AHORRO ECONÓMICO EN LA SITUACIÓN MEJORADA AL AÑO 0	233,71 €
Vida útil de la medida (años)	25
Ahorro total neto (A·VU)	5.842,81 €
Inversión total (equipos, mano obra...) (€)	3.330,00 €
Periodo de amortización bruta (años)	14,25
Rendimiento bruto de la inversión (%)	75%
Rendimiento bruto anual de la inversión (%) (RGB/VU)	3%
Depreciación anual de la inversión (€)	133,20 €
Año de estudio	10
Ahorro total neto año de estudio (A·AE)	2.337,12 €
Tasa de retorno de la inversión (TRI) (%)	30%

In the table you can see the values obtained for:

- Gross amortization period: 14.25 years over 25 useful life.

- RBA: annual yield of 3% on a total RGB of 75% in the useful life of 25 years.

- Internal rate of return of 30% for the year of study 10 over the useful life of 25 years.

It is therefore a profitable investment, although it requires a long amortization period. A greater profitability could be obtained if only the placement of the insulation is proceeded.

Calculation of future time indicators:

In this case, the two most common indicators are presented, such as the NPV and the IRR. For its calculation, the forecast of future evolution of some parameters is needed, such as a 5% average increase in energy prices, 2% of the CPI and a 3% discount rate.

As for the costs of evolution over time, they will be considered 0, since being a measure on the envelope would not be necessary to do anything.

Developing the equations of annual cash flows provides that:

In this case, the NPV becomes positive in year 13 (the amortization period was 14.25 years).

The IRR is 10% at the end of the useful life (well above the 3% desired as the discount rate or opportunity cost).

Inversión inicial	3.330,00 €
Ahorro económico anual	233,71 €
Costes de mantenimiento anuales	0,00
Incremento de los precios de la energía:	5,00%
Tasa de inflación prevista (IPC):	2,00%
Tasa de descuento - Coste de oportunidad:	3,00%
Tipo de interés bancario	5%

AISLAMIENTO DE CUBIERTAS

Plazo (años)	Ingresos - Ahorros	Gastos - Costes	Flujo de caja	VAN al año en curso	TIR año en curso
Inversión inicial - Año 0	- €	3.330,00 €	-3.330,00 €		
Año 1	245,40 €	0,00 €	245,40 €	-3.091,75	#¡NUM!
Año 2	257,67 €	0,00 €	257,67 €	-2.848,87	#¡NUM!
Año 3	270,55 €	0,00 €	270,55 €	-2.601,28	#¡NUM!
Año 4	284,08 €	0,00 €	284,08 €	-2.348,88	-34%
Año 5	298,28 €	0,00 €	298,28 €	-2.091,58	-23%
Año 6	313,20 €	0,00 €	313,20 €	-1.829,28	-16%
Año 7	328,86 €	0,00 €	328,86 €	-1.561,89	-11%
Año 8	345,30 €	0,00 €	345,30 €	-1.289,31	-7%
Año 9	362,56 €	0,00 €	362,56 €	-1.011,43	-4%
Año 10	380,69 €	0,00 €	380,69 €	-728,16	-1%
Año 11	399,73 €	0,00 €	399,73 €	-439,39	1%
Año 12	419,71 €	0,00 €	419,71 €	-145,01	2%
Año 13	440,70 €	0,00 €	440,70 €	155,08	4%
Año 14	462,73 €	0,00 €	462,73 €	461,00	5%
Año 15	485,87 €	0,00 €	485,87 €	772,87	6%
Año 16	510,16 €	0,00 €	510,16 €	1.090,78	6%
Año 17	535,67 €	0,00 €	535,67 €	1.414,88	7%
Año 18	562,46 €	0,00 €	562,46 €	1.745,26	8%
Año 19	590,58 €	0,00 €	590,58 €	2.082,06	8%
Año 20	620,11 €	0,00 €	620,11 €	2.425,40	9%
Año 21	651,11 €	0,00 €	651,11 €	2.775,40	9%
Año 22	683,67 €	0,00 €	683,67 €	3.132,20	9%
Año 23	717,85 €	0,00 €	717,85 €	3.495,93	10%
Año 24	753,75 €	0,00 €	753,75 €	3.866,73	10%
Año 25	791,43 €	0,00 €	791,43 €	4.244,72	10%

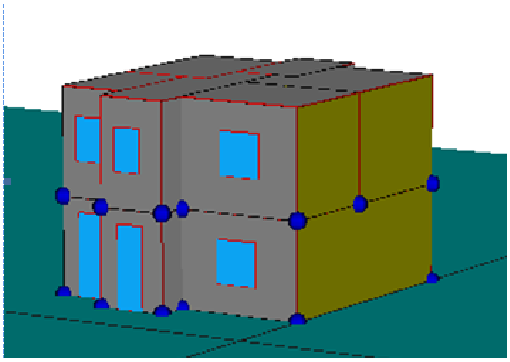
The rehabilitation and improvement of roof insulation is another easily implemented measure. Neighboring communities are quite receptive to this proposal, especially in the event that some type of maintenance or repair action is required on the roof.

In this case the approach of the return of the investment in a term of between 12-14 years taking into account a useful life around 25 years is easy to argue and accept.

It is a measure very similar to the placement of façade insulation systems.

5. Actions in improvement of insulation in floors

It starts from the basis of the previous example, a single-family housing building.



STEP 1 - Approach of the energy efficiency measure - IMPROVEMENT OF THE INSULATION IN THE SOIL

In this example, a measure of thermal insulation of the floor of the house is proposed to reduce heat losses in that area.

In the case of floors, the thermal insulation is placed on the concrete slab. Between the insulator and the mortar it is necessary to place a polyethylene sheet that acts as an impermeable barrier.

This action on the envelope works with the same concepts as the action on the facade and roof. The improvement of soil insulation is based on the principle of the reduction of thermal transmittance. In this way, energy losses are minimized by this part of the enclosure and the energy demand needed by the building to maintain comfort conditions is reduced.

On the contrary, it is a measure of more difficult acceptance since it requires interior actions that always generate small temporary inconveniences to the neighbors.

STEP 2. Calculation of the INITIAL AND FINAL demand of heating and cooling energy

The starting point is the same as in the previous example. That is to say:

SITUACIÓN DE INICIO	
DEMANDA DE ENERGÍA ÚTIL INICIAL DE LA VIVIENDA	
Demanda útil total de calefacción y ACS (KWh/año)	**8473,52**
Demanda útil total de refrigeración (KWh/año)	**1850,25**

Once the changes in the model corresponding to the measure to be executed have been made, the new useful energy demand values are available:

SITUACIÓN MEJORADA FINAL	
DEMANDA DE ENERGÍA ÚTIL FINAL DE LA VIVIENDA	
Demanda útil total de calefacción y ACS (KWh/año)	**6254**
Demanda útil total de refrigeración (KWh/año)	**1366**

STEP 3. Calculation of the INITIAL and FINAL average seasonal performance of the installation of heat and cold

In the example, the installation has a 4KW heat pump for cooling (heating is done with the boiler) with a SEER of 2.6 = 260%

RENDIMIENTO ESTACIONAL MEDIO INSTALACIONES	
Rendimiento estacional medio CALDERA	93%
Rendimiento estacional medio BOMBA DE CALOR	260%

The returns of the improved situation are the same since they are not acted on.

STEP 4. Calculation of the contribution of renewable energies INITIAL AND FINAL

Assess the energy contribution of renewable energy sources to the demand of the system.

No renewable energy is contributed to the system.

STEP 5. Calculation of INITIAL and FINAL energy consumption.

The data on the demand for useful energy, the performance of the facilities and the contribution of renewable energy are available. The calculation of the final energy demand is made for the initial and final situations.

SITUACIÓN DE INICIO	
DEMANDA DE ENERGÍA ÚTIL INICIAL DE LA VIVIENDA	
Demanda útil total de calefacción y ACS (KWh/año)	8473,52
Demanda útil total de refrigeración (KWh/año)	1850,25
RENDIMIENTO ESTACIONAL MEDIO INSTALACIONES	
Rendimiento estacional medio CALDERA de GAS NATURAL	93%
Rendimiento estacional medio BOMBA DE CALOR ELECTRICA	260%
DEMANDA DE ENERGÍA FINAL INICIAL DE LA VIVIENDA	
Demanda final de calefacción y ACS EN GAS NATURAL (KWh/año)	9111,31
Demanda final total de refrigeración en ELECTRICIDAD (KWh/año)	711,63

By performing the same steps with the values of the improved situation you get:

SITUACIÓN MEJORADA FINAL	
DEMANDA DE ENERGÍA ÚTIL FINAL DE LA VIVIENDA	
Demanda útil total de calefacción y ACS (KWh/año)	6254
Demanda útil total de refrigeración (KWh/año)	1366
RENDIMIENTO ESTACIONAL MEDIO INSTALACIONES	
Rendimiento estacional medio CALDERA de GAS NATURAL	93%
Rendimiento estacional medio BOMBA DE CALOR ELECTRICA	260%
DEMANDA DE ENERGÍA FINAL DE LA VIVIENDA	
Demanda final de calefacción y ACS EN GAS NATURAL (KWh/año)	6724,73
Demanda final total de refrigeración en ELECTRICIDAD (KWh/año)	525,38

STEP 6. Evolution of fuel prices.

The table exposed in the previous topic will be used.

Coste combustible	€/Kwh	% Incremento anual
Electricidad	0,170	6,00%
Gas natural	0,060	5,00%
Gasoil	0,096	5,00%
Fuel-oil	0,102	5,00%
GLP	0,120	5,00%
Carbón	0,130	4,00%
Pellets	0,053	2,50%
Biomasa (otro tipo)	0,380	1,00%
Energías renovables	0,000	0,00%

Fuel costs and estimated annual percentage increase. Own elaboration

STEP 7. Calculation of ECONOMIC SAVINGS between INITIAL and FINAL situation.

At this point it will be necessary to calculate the annual economic savings between the initial (present) and final (future) situations with fuel consumption.

The fuel savings will be, therefore:

GASTO PREVIO A LA MEDIDA Gasto en combustible INICIAL = (Cantidad de combustible INICIAL) **x** (Precio del combustible)
GASTO POSTERIOR A LA MEDIDA Gasto en combustible FINAL = (Cantidad de combustible FINAL) x (Precio del combustible)
AHORRO ECONÓMICO: (Gasto en combustible FINAL) - (Gasto en combustible INICIAL)

It is important to keep in mind that there may be facilities that have more than one fuel. For example, gas and electricity, gas and biomass ... in these cases the total savings will be the sum of the savings of each of the fuels used.

PRECIO DE LOS COMBUSTIBLES A TIEMPO PRESENTE	
Gas Natural (€/KWh)	**0,06**
Electricidad (€/KWh)	**0,17**
COSTE EN COMBUSTIBLE INICIAL	
Coste en GAS NATURAL para calefacción y ACS	**546,68 €**
Coste en ELECTRICIDAD para refrigeración	**120,98 €**
TOTAL COSTE EN COMBUSTIBLE INICIAL	**667,66 €**

PRECIO DE LOS COMBUSTIBLES A TIEMPO PRESENTE	
Gas Natural (€/KWh)	0,06
Electricidad (€/KWh)	0,17
COSTE EN COMBUSTIBLE FINAL	
Coste en GAS NATURAL para calefacción y ACS	403,48 €
Coste en ELECTRICIDAD para refrigeración	89,32 €
TOTAL COSTE EN COMBUSTIBLE FINAL	**492,80 €**
AHORRO ECONÓMICO EN LA SITUACIÓN MEJORADA AL AÑO 0	**174,86 €**

If you intend to do a NPV or IRR calculation for several years of study, you will need to make an annual estimate of cash flow so that the annual economic savings will not only be savings in energy fuel but also, for example, savings in energy, maintenance costs, spending on bank loan installments or any other modification of the initial situation with the future.

STEP 8. Valuation of the investment: EQUIPMENT, MATERIALS, LABOR...

In this case, the measure will be considered before making changes in the ground. That is, the only investment corresponds to the installation of the polyethylene sheet. The rest of the elements: parquet ... would be placed the same and does not suppose an excess of cost.

A thermal and acoustic insulation of floating floors is made up of a rigid panel of mineral wool, uncoated, 40 mm thick, thermal resistance 1.1 m²K / W, thermal conductivity 0.035 W / (mK), covered with polyethylene film 0.2 mm thick, prepared to receive a screed mortar or concrete (not included in this price).

INVERSIÓN INICIAL	
MANO DE OBRA Coste colocación €/m2	3
COSTE DE MATERIAL Coste del aislante €/m2	10
MEDIOS AUXILIARES Andamios €/m2	1
COSTES INDIRECTOS Proyectos, tasas €/m2	2
Superficie de aislamiento de suelo	90
TOTAL INVERSION	1.440,00 €

STEP 9. Estimation of the future evolution of important variables in the economic analysis: CPI, interest rates ...

It also assumes a 5% average increase in energy prices, 2% of the CPI and a 3% discount rate.

STEP 10. Assessment of the possibility of subsidies, external financing, credits ...

The need for external financing or subsidies is not considered in this case. It will be done with own funds.

STEP 11. Final economic and viability analysis: Amortization period, NPV, IRR ...

You already have all the necessary data for the calculation of the different indicators that have been raised.

Some present time as the gross amortization period, RGB, TRI ... and others in future time such as the NPV, the IRR or the B / C ratio.

<u>Calculation of the present time indicators:</u>

INDICADORES A TIEMPO PRESENTE	
AHORRO ECONÓMICO EN LA SITUACIÓN MEJORADA AL AÑO 0	174,86 €
Vida útil de la medida (años)	25
Ahorro total neto (A·VU)	4.371,43 €
Inversión total (equipos, mano obra...) (€)	1.440,00 €
Periodo de amortización bruta (años)	8,24
Rendimiento bruto de la inversión (%)	204%
Rendimiento bruto anual de la inversión (%) (RGB/VU)	8%
Depreciación anual de la inversión (€)	57,60 €
Año de estudio	10
Ahorro total neto año de estudio (A·AE)	1.748,57 €
Tasa de retomo de la inversión (TRI) (%)	81%

In the table you can see the values obtained for:

- Gross amortization period: 8 years over 25 useful life.

- RBA: yield of 8% per year on a total RGB of 204% in the useful life of 25 years.

- Internal rate of return of 81% for the year of study 10 over the useful life of 25 years.

It is therefore a profitable investment.

Calculation of future time indicators:

In this case, the two most common indicators are presented, such as the NPV and the IRR. For its calculation, the forecast of future evolution of some parameters is needed, such as a 5% average increase in energy prices, 2% of the CPI and a 3% discount rate.

As for the costs of evolution over time, they will be considered 0, since being a measure on the envelope would not be necessary to do anything.

Developing the equations of annual cash flows provides that:

In this case, the NPV becomes positive in year 8 (the amortization period was 8.24 years).

The IRR is 17% at the end of the useful life (well above the 3% desired as the discount rate or opportunity cost).

Inversión inicial	1.440,00 €
Ahorro económico anual	174,86 €
Costes de mantenimiento anuales	0,00
Incremento de los precios de la energía:	5,00%
Tasa de inflación prevista (IPC):	2,00%
Tasa de descuento - Coste de oportunidad:	3,00%
Tipo de interés bancario	5%

AISLAMIENTO DE SUELOS

Plazo (años)	Ingresos - Ahorros	Gastos - Costes	Flujo de caja	VAN al año en curso	TIR año en curso
Inversión inicial - Año 0	- €	1.440,00 €	-1.440,00 €		
Año 1	183,60 €	0,00 €	183,60 €	-1.261,75	#¡NUM!
Año 2	192,78 €	0,00 €	192,78 €	-1.080,03	#¡NUM!
Año 3	202,42 €	0,00 €	202,42 €	-894,79	#¡NUM!
Año 4	212,54 €	0,00 €	212,54 €	-705,95	-20%
Año 5	223,17 €	0,00 €	223,17 €	-513,45	-10%
Año 6	234,33 €	0,00 €	234,33 €	-317,20	-4%
Año 7	246,04 €	0,00 €	246,04 €	-117,15	1%
Año 8	258,34 €	0,00 €	258,34 €	86,79	4%
Año 9	271,26 €	0,00 €	271,26 €	294,69	7%
Año 10	284,82 €	0,00 €	284,82 €	506,63	9%
Año 11	299,07 €	0,00 €	299,07 €	722,68	10%
Año 12	314,02 €	0,00 €	314,02 €	942,92	12%
Año 13	329,72 €	0,00 €	329,72 €	1.167,45	13%
Año 14	346,21 €	0,00 €	346,21 €	1.396,33	13%
Año 15	363,52 €	0,00 €	363,52 €	1.629,66	14%
Año 16	381,69 €	0,00 €	381,69 €	1.867,51	15%
Año 17	400,78 €	0,00 €	400,78 €	2.109,99	15%
Año 18	420,82 €	0,00 €	420,82 €	2.357,18	15%
Año 19	441,86 €	0,00 €	441,86 €	2.609,16	16%
Año 20	463,95 €	0,00 €	463,95 €	2.866,04	16%
Año 21	487,15 €	0,00 €	487,15 €	3.127,90	16%
Año 22	511,50 €	0,00 €	511,50 €	3.394,85	16%
Año 23	537,08 €	0,00 €	537,08 €	3.666,98	17%
Año 24	563,93 €	0,00 €	563,93 €	3.944,40	17%
Año 25	592,13 €	0,00 €	592,13 €	4.227,21	17%

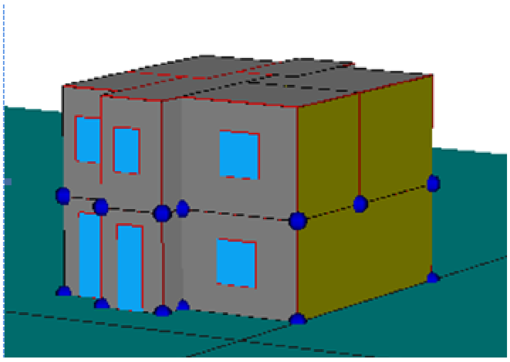
It is therefore a measure of rapid recovery (around 8-10 years).

On the contrary, it is not usually a habitual measure in energy rehabilitation taking into account the disorders that originates the owners since in this case the reform is done inside. The improvement in facades and roofs are the measures currently undertaken as a priority.

In any case, the performance is profitable and a correct exposure of the measure accompanied by an excellent execution of the same has very fast return on investment.

6. Actions in improvement of air conditioning installations

It starts from the basis of the previous example, a single-family housing building.



STEP 1 - Approach of the energy efficiency measure - IMPROVEMENT OF THE PERFORMANCE OF THE AIR CONDITIONING FACILITIES

In this example, it is not going to act on the envelope as in the previous cases but it will be done by increasing the performance of the facilities.

A boiler change is going to be considered. The current natural gas with a yield of 93% by a condensing boiler with an overall performance of 106% (for its capacity to take advantage of the humidity of the combustion gases, is higher than 100%).

In this case, the objective is to increase the performance of the facilities that generate heat and cold so that the final consumption is lower.

The heat pump for cooling with 260% performance with energy label F will be replaced with another 480% performance energy label B.

The two changes are proposed, although in reality, with the existing technologies, the gas boiler for heating could be eliminated since the pump could supply heating and cooling.

Heat pump for cooling and condensing boiler

STEP 2. Calculation of the INITIAL AND FINAL demand of heating and cooling energy

The starting point is the same as in the previous example. That is to say:

SITUACIÓN DE INICIO	
DEMANDA DE ENERGÍA ÚTIL INICIAL DE LA VIVIENDA	
Demanda útil total de calefacción y ACS (KWh/año)	**8473,52**
Demanda útil total de refrigeración (KWh/año)	**1850,25**

By not acting on the demand the values after the performance are the same:

SITUACIÓN MEJORADA FINAL	
DEMANDA DE ENERGÍA ÚTIL FINAL DE LA VIVIENDA	
Demanda útil total de calefacción y ACS (KWh/año)	**8473,52**
Demanda útil total de refrigeración (KWh/año)	**1850,25**

STEP 3. Calculation of the INITIAL and FINAL average seasonal performance of the installation of heat and cold

This is where the new performances of both machines now act, so that initially:

RENDIMIENTO ESTACIONAL MEDIO INSTALACIONES	
Rendimiento estacional medio CALDERA	93%
Rendimiento estacional medio BOMBA DE CALOR	260%

On the contrary, the performances of the improved situation are:

RENDIMIENTO ESTACIONAL MEDIO INSTALACIONES	
Rendimiento estacional medio CALDERA de GAS NATURAL	**106%**
Rendimiento estacional medio BOMBA DE CALOR ELECTRICA	**480%**

STEP 4. Calculation of the contribution of renewable energies INITIAL AND FINAL

Assess the energy contribution of renewable energy sources to the demand of the system.

No renewable energy is contributed to the system.

STEP 5. Calculation of INITIAL and FINAL energy consumption.

The data on the demand for useful energy, the performance of the facilities and the contribution of renewable energy are available. The calculation of the final energy demand is made for the initial and final situations.

SITUACIÓN DE INICIO	
DEMANDA DE ENERGÍA ÚTIL INICIAL DE LA VIVIENDA	
Demanda útil total de calefacción y ACS (KWh/año)	**8473,52**
Demanda útil total de refrigeración (KWh/año)	**1850,25**
RENDIMIENTO ESTACIONAL MEDIO INSTALACIONES	
Rendimiento estacional medio CALDERA de GAS NATURAL	**93%**
Rendimiento estacional medio BOMBA DE CALOR ELECTRICA	**260%**
DEMANDA DE ENERGÍA FINAL INICIAL DE LA VIVIENDA	
Demanda final de calefacción y ACS EN GAS NATURAL (KWh/año)	**9111,31**
Demanda final total de refrigeración en ELECTRICIDAD (KWh/año)	**711,63**

By performing the same steps with the values of the improved situation you get:

SITUACIÓN MEJORADA FINAL	
DEMANDA DE ENERGÍA ÚTIL FINAL DE LA VIVIENDA	
Demanda útil total de calefacción y ACS (KWh/año)	8473,52
Demanda útil total de refrigeración (KWh/año)	1850,25
RENDIMIENTO ESTACIONAL MEDIO INSTALACIONES	
Rendimiento estacional medio CALDERA de GAS NATURAL	106%
Rendimiento estacional medio BOMBA DE CALOR ELECTRICA	480%
DEMANDA DE ENERGÍA FINAL DE LA VIVIENDA	
Demanda final de calefacción y ACS EN GAS NATURAL (KWh/año)	7993,89
Demanda final total de refrigeración en ELECTRICIDAD (KWh/año)	385,47

STEP 6. Evolution of fuel prices.

The table exposed in the previous topic will be used

Coste combustible	€/Kwh	% Incremento anual
Electricidad	0,170	6,00%
Gas natural	0,060	5,00%
Gasoil	0,096	5,00%
Fuel-oil	0,102	5,00%
GLP	0,120	5,00%
Carbón	0,130	4,00%
Pellets	0,053	2,50%
Biomasa (otro tipo)	0,380	1,00%
Energías renovables	0,000	0,00%

Fuel costs and estimated annual percentage increase. Own elaboration

STEP 7. Calculation of ECONOMIC SAVINGS between INITIAL and FINAL situation.

At this point it will be necessary to calculate the annual economic savings between the initial (present) and final (future) situations with fuel consumption.

The fuel savings will be, therefore:

GASTO PREVIO A LA MEDIDA Gasto en combustible INICIAL = (Cantidad de combustible INICIAL) **x** (Precio del combustible)
GASTO POSTERIOR A LA MEDIDA Gasto en combustible FINAL = (Cantidad de combustible FINAL) x (Precio del combustible)
AHORRO ECONÓMICO: (Gasto en combustible FINAL) - (Gasto en combustible INICIAL)

It is important to keep in mind that there may be facilities that have more than one fuel. For example, gas and electricity, gas and biomass ... in these cases the total savings will be the sum of the savings of each of the fuels used.

PRECIO DE LOS COMBUSTIBLES A TIEMPO PRESENTE	
Gas Natural (€/KWh)	**0,06**
Electricidad (€/KWh)	**0,17**
COSTE EN COMBUSTIBLE INICIAL	
Coste en GAS NATURAL para calefacción y ACS	**546,68 €**
Coste en ELECTRICIDAD para refrigeración	**120,98 €**
TOTAL COSTE EN COMBUSTIBLE INICIAL	**667,66 €**

PRECIO DE LOS COMBUSTIBLES A TIEMPO PRESENTE	
Gas Natural (€/KWh)	**0,06**
Electricidad (€/KWh)	**0,17**
COSTE EN COMBUSTIBLE FINAL	
Coste en GAS NATURAL para calefacción y ACS	**479,63 €**
Coste en ELECTRICIDAD para refrigeración	**65,53 €**
TOTAL COSTE EN COMBUSTIBLE FINAL	**545,16 €**
AHORRO ECONÓMICO EN LA SITUACIÓN MEJORADA AL AÑO 0	**122,49 €**

If you intend to make a calculation type NPV or TIR to several years of study will be necessary to make an annual estimate of cash flow so that the annual economic savings will not only be savings in fuel energy but also, for example, cost savings of maintenance, the expense in installments of bank loans or any other modification of the initial situation with the future.

STEP 8. Valuation of the investment: EQUIPMENT, MATERIALS, LABOR...

The measure in this case consists of the replacement of the air conditioning equipment. Therefore, two machine changes are proposed. The replacement of the boiler that generates the heating and the ACS for another one with a higher performance and replacement of the air conditioning machine by another more efficient heat pump.

INVERSIÓN INICIAL		
Instalación de la bomba de calor	2500	€/ud
Instalación de la caldera	3300	€/m2
TOTAL INVERSION	5.800,00 €	I

STEP 9. Estimation of the future evolution of important variables in the economic analysis: CPI, interest rates...

It also assumes a 5% average increase in energy prices, 2% of the CPI and a 3% discount rate.

STEP 10. Assessment of the possibility of subsidies, external financing, credits...

The need for external financing or subsidies is not considered in this case. It will be done with own funds.

STEP 11. Final economic and viability analysis: Amortization period, NPV, IRR...

We already have all the necessary data for the calculation of the different indicators that have been raised: some at present time such as the gross amortization period, RGB, TRI ... and others in future time such as the NPV, the IRR or the B / C ratio.

Calculation of the present time indicators:

INDICADORES A TIEMPO PRESENTE		
AHORRO ECONÓMICO EN LA SITUACIÓN MEJORADA AL AÑO 0	122,49 €	A
Vida útil de la medida (años)	25	VU
Ahorro total neto (A·VU)	3.062,34 €	AN
Inversión total (equipos, mano obra...) (€)	5.800,00 €	I
Periodo de amortización bruta (años)	47,35	PB
Rendimiento bruto de la inversión (%)	-47%	RGB
Rendimiento bruto anual de la inversión (%) (RGB/VU)	-2%	RBA
Depreciación anual de la inversión (€)	232,00 €	D
Año de estudio	10	AE
Ahorro total neto año de estudio (A·AE)	1.224,94 €	ANE
Tasa de retorno de la inversión (TRI) (%)	-19%	TRI

In the table you can see the values obtained for:

- Gross amortization period: 47 years over 15 of useful life (it is an installation)
- RBA: yield of -2% per annum over a total RGB of -47% over the 15-year lifespan
- Internal rate of return of -19% for the year of study 10 over the useful life of 15 years

It is therefore an unprofitable investment.

The problem in this case is that the initial situation had relatively good facilities. It has been improved but the investment cost can't be amortized with annual benefits.

In this case it would be more logical to eliminate the gas boiler system, and do everything with the heat pump, although the installation cost would also increase because adaptations would have to be made.

Calculation of future time indicators:

In this case, the two most common indicators are presented, such as the NPV and the IRR. For its calculation, the forecast of future evolution of some parameters is needed, such as a 5% average increase in energy prices, 2% of the CPI and a 3% discount rate.

Regarding the costs of evolution over time, they will be considered 0, since they are intended to perform the same maintenance as in the start-up situation.

Developing the equations of annual cash flows provides that:

In this case, the NPV does not become positive (the amortization period was 47 years).

The IRR is 0% at the end of the useful life, still less than 3% of the discount rate or opportunity cost chosen.

As explained in the present-time indicators, the performance with the chosen parameters would not be profitable.

Inversión inicial	5.800,00 €
Ahorro económico anual	122,49 €
Costes de mantenimiento anuales	0,00
Incremento de los precios de la energía:	5,00%
Tasa de inflación prevista (IPC):	2,00%
Tasa de descuento - Coste de oportunidad:	3,00%
Tipo de interés bancario	5%

SUSTITUCIÓN DE INSTALACIONES

Plazo (años)	Ingresos - Ahorros	Gastos - Costes	Flujo de caja	VAN al año en curso	TIR año en curso
Inversión inicial - Año 0	- €	5.800,00 €	-5.800,00 €		
Año 1	128,62 €	0,00 €	128,62 €	-5.675,13	#¡NUM!
Año 2	135,05 €	0,00 €	135,05 €	-5.547,83	#¡NUM!
Año 3	141,80 €	0,00 €	141,80 €	-5.418,06	#¡NUM!
Año 4	148,89 €	0,00 €	148,89 €	-5.285,77	#¡NUM!
Año 5	156,34 €	0,00 €	156,34 €	-5.150,92	#¡NUM!
Año 6	164,15 €	0,00 €	164,15 €	-5.013,44	#¡NUM!
Año 7	172,36 €	0,00 €	172,36 €	-4.873,30	#¡NUM!
Año 8	180,98 €	0,00 €	180,98 €	-4.730,43	-25%
Año 9	190,03 €	0,00 €	190,03 €	-4.584,79	#¡NUM!
Año 10	199,53 €	0,00 €	199,53 €	-4.436,32	#¡NUM!
Año 11	209,51 €	0,00 €	209,51 €	-4.284,97	#¡NUM!
Año 12	219,98 €	0,00 €	219,98 €	-4.130,68	#¡NUM!
Año 13	230,98 €	0,00 €	230,98 €	-3.973,39	-11%
Año 14	242,53 €	0,00 €	242,53 €	-3.813,05	-9%
Año 15	254,66 €	0,00 €	254,66 €	-3.649,60	-7%
Año 16	267,39 €	0,00 €	267,39 €	-3.482,97	-6%
Año 17	280,76 €	0,00 €	280,76 €	-3.313,11	-5%
Año 18	294,80 €	0,00 €	294,80 €	-3.139,95	-4%
Año 19	309,54 €	0,00 €	309,54 €	-2.963,42	-3%
Año 20	325,01 €	0,00 €	325,01 €	-2.783,47	-2%
Año 21	341,26 €	0,00 €	341,26 €	-2.600,02	-2%
Año 22	358,33 €	0,00 €	358,33 €	-2.413,02	-1%
Año 23	376,24 €	0,00 €	376,24 €	-2.222,38	-1%
Año 24	395,05 €	0,00 €	395,05 €	-2.028,04	0%
Año 25	414,81 €	0,00 €	414,81 €	-1.829,92	0%

In the calculations that have been made, the two changes have been proposed: heat machines (boiler) and cold machines (heat pump).

The high investment in new equipment means that the investment is not profitable, derived mainly from the low demand of cold that the example has. By the results obtained it is perceived that it does not make sense to replace all cold equipment for the needs that it has. The change is not profitable over time.

On the other hand, if the elimination of a device (for example, the boiler) and the substitution of this by an integral machine (cold, heat, DHW ...) type high efficiency heat pump, the measure would be profitable and much more effective.

7. Actions in improvement of lighting installations

The actions in lighting installations tend to be of rapid amortization ... there are no large investments and with the LED technologies and electronic ballasts the size of the operation is quickly recovered.

In this case two examples are proposed and only the amortization period is calculated since the recovery periods are fast.

Example of replacing T8 fluorescent lamps with T5

It is proposed to change 100 T8 fluorescent lamps of 36W from one office to 40 T5 fluorescent lamps of 28W. Assuming an average of 1000 annual hours of use for each of them (100,000 hours in total), you would have savings of:

Tipo de lámpara	Potencia (W)	Potencia + Balasto (W)	Tiempo (hr/año)	Consumo (KWh)	Ahorro energético (KWh)
Fluorescente T8 + Balasto electromagnético	36	45	100000	4500	
Fluorescente T5 + Balasto eléctrónico	26	26,52	100000	2652	1848

If the energy saving in euros is quantified with an average price of 0.17 € / Kwh, there would be a direct annual saving in lighting consumption of:

Tipo de lámpara	Ahorro energético (KWh)	Precio medio KWh	Ahorro económico anual (€)
Fluorescente T8 + Balasto electromagnético		0,17 €	
Fluorescente T5 + Balasto eléctrónico	1848	0,17 €	314,16 €

As for the amortization of the investment, assuming that the replacement of the luminaire is not necessary, a T5 lamp can be around € 4 while the ballast exchange about € 28. It is calculated the replacement of the 100 lamps (400 €) and about 40 ballasts

(1120 €) in account the assembly and that many luminaries have several lamps (there is no need to change ballast for lamps but for luminaire)

Tipo de lámpara	Ahorro económico anual (€)	Inversión total (€)	Amortización en años
Fluorescente T8 + Balasto electromagnético			
Fluorescente T5 + Balasto eléctrónico	314,16 €	1.520,00 €	4,8

With these prices the low consumption is amortized in about 5 years. It is a reasonable enough time, although a significant volume of lamps is required for the values to be found in these parameters.

This same calculation could be done with LED technology.

Example of replacement of complete luminaires

It is proposed the replacement of the luminaires of an office. Currently there are 8 luminaires with 4 tubes of 18W each with electromagnetic ballasts.

An annual use of 1840 hours per lamp is calculated (8x4x1840 = 58880 hours in total)

The new luminaires use 4 14W tubes and incorporate electronic ballasts. The level of light obtained is the same.

The annual energy savings would be:

Tipo de lámpara	Potencia (W)	Potencia + Balasto (W)	Tiempo (hr/año)	Consumo (KWh)	Ahorro energético (KWh)
Luminaria 4x18W. Balasto electromagnético	18	22,5	58880	1324,8	
Luminaria 4x14W. Balasto electrónico	14	14,28	58880	840,8064	483,9936

If the energy saving in euros is quantified with an average price of 0.17 € / Kwh, there would be a direct annual saving in lighting consumption of:

Tipo de lámpara	Ahorro energético (KWh)	Precio medio KWh	Ahorro económico anual (€)
Luminaria 4x18W. Balasto electromagnético		0,17 €	
Luminaria 4x14W. Balasto electrónico	483,9936	0,17 €	82,28 €

As for the amortization of the investment, assuming an investment cost of € 75 per luminaire (€ 8x75 = € 600):

Tipo de lámpara	Ahorro económico anual (€)	Inversión total (€)	Amortización en años
Luminaria 4x18W. Balasto electromagnético			
Luminaria 4x14W. Balasto electrónico	82,28 €	600,00 €	7,3

The installation would be amortized in 7 years, an average return period.

The replacement of old lighting equipment (lamps, luminaires and auxiliary equipment) with technology is one of the most rapidly depreciable energy efficiency measures. The saving in energy consumption of the lamps means that the return in some cases does not exceed 3 years (provided that it is not necessary to change luminaires).

8. Development of models of profitability proposals in energy efficiency measures for clients

Once the feasibility and feasibility study of the energy saving measure has been completed, the final report will be drafted, a summary of the results obtained and conclusions will be provided for further study and evaluation of the final client.

This last point, to which little importance is usually given, is vital since with all the information that is delivered, the client will finally make the decision to implement or not the energy rehabilitation measure.

The work done can be inconsequential if the technician is not able to clearly explain the results obtained: investments can be high and it is necessary to convince the client that the decision is appropriate assuming the minimum risk.

The objective is to convince the client and, for this, it will be necessary to provide convincing data, based on demonstrable and easy to understand values. The presentation of the results will be fundamental.

> *Most of the clients (except for large professional investors) do not have knowledge in economics, or viability, or in bank loans.*
>
> *Not all customers are the same but the presentation of the data is essential to convince them that the investment will be viable and profitable.*

If a lot of information is presented and very technical, the client can be lost. For example, an exhaustive analysis of the data of the NPV or the IRR with the explanation of all the supposed parameters of evolution, usually gives very bad results because the client is not familiar with the terms and is lost among the numbers.

Even the mere exposure of the terms NPV, IRR, discount rate, CPI ... are often unconvincing. They are very important in the study because they are the ones that effectively define the profitability and viability of the project, but the client does not usually understand them.

> *Always with exceptions, but normally it is more effective to expose clear final data that allows easy measurement of the degree of recovery of the investment: years, euros, terms...*

For example, show the annual economic savings of the measure, the term in years of recovery of the investment or the economic savings generated during a certain period of time.

These values are much more understandable and easy to understand by the client.

Even so, the most usual thing is that the client has questions that require certain concretion. Any product must be specified to reach the final agreement and allow the client to make the final decision.

This means that we will discuss possible modifications, approximate dates of initiation, prices or investments to be made, payment methods, guarantees and other specific conditions of the service provided that end up closing the project.

9. Actions of support, awareness and promotion of energy efficiency as a strategy of economic profitability

The European Union has defined 3 strategic pillars in energy policy since the beginning of the 21st century.

- Reduction of dependence on fossil fuel imports

- Competition for resources and energy

- The effects of climate change: economy, health and quality of life

Based on this basis, quantitative objectives have been developed in terms of energy efficiency. For example, for the year 2020:

- 20% reduction of CO_2 emissions to the atmosphere

- 20% share of renewable energy.

- 20% improvement in energy efficiency.

In recent years these objectives have been updated with the focus in the year 2030.

- 40% reduction of CO_2 emissions to the atmosphere

- 27% share of renewable energy

- 27% improvement in energy efficiency

They are ambitious objectives and only with the collaboration of all can achieve to meet them.

To achieve this, there are several work areas:

- Reduction of energy demand of buildings.

- Increase of the performance of the facilities.

- Promotion of renewable energies

In Spain, regulatory steps have been taken to follow the strategy set by the European Union, such as the Technical Building Code and the Regulation for Thermal Installations.

This reduction in electricity consumption has several benefits both at the user level and at the environmental level.

The economic is the most obvious and obvious benefit. A lower consumption of electricity leads to a reduction in the final cost of the electricity bill. The end user is the great beneficiary of this situation.

The second is the environment. The combustion of the aforementioned non-renewable primary energy sources (natural gas, coal or oil) generates large amounts of CO_2 emissions into the atmosphere. The reduction in its use also implies a minimization of the emission of these gases that cause the greenhouse effect. This contributes to a generation that is much cleaner and more environmentally sustainable.

In summary, the implementation of energy efficiency measures offers multiple benefits for both the user and the environment.

The promotion of these measures appealing to their economic profitability as well as environmental awareness should be a priority for the next few years in Spain and Europe.

This project has received funding from the INTERREG SUDOE Program (Project Identification Number: SOE1 / P3 / E0294) of the European Regional Development Fund (ERDF) of the European Union.

The content reflects only the point of view of the authors and, consequently, does not represent in any case the official opinion of the management bodies of the Program.

Unit 1: Building evaluation: general information, envelope and facilities

1.- The energy consumption is: a. The quotient between the demand for energy and the performance of the facilities. b. The quotient between the performance of the facilities and the demand for energy. c. The contribution of renewable energies less the demand for energy
2.- By the year 2030, the European Union proposes a reduction in the emission of greenhouse gases from: a. 20% b. 30% c. 40%
3.- By 2020, the European Union proposes a reduction in the emission of greenhouse gases from: a. 20% b. 30% c. 40%
4.- For year 202 0 the European Union proposes a minimum contribution of renewable energies from: a. 20% b. 30% c. 40%
5.- The phase that aims to characterize the energy efficiency of the object of study and then optimize its operation is called a. Energy audit b. Determination of pathologies and possibilities for improvement c. Evaluation: Solutions and adNPVtages d. Study of economic profitability and financing e. Execution. Quality and guarantees f. Monitoring and maintenance
6.- The phase that pretends it is tried to realize a previous list with the possible and habitual measures of energetic efficiency that are going to be later object of study to realize an intervention. a. Energy audit b. Determination of pathologies and possibilities for improvement c. Evaluation: Solutions and advantages

d. Study of economic profitability and financing e. Execution. Quality and guarantees f. Monitoring and maintenance
7.- The NPV and the IRR are: a. Energy efficiency indicators b. Profitability indicators of an investment c. Quality indicators of the execution of a measure
8.- Poor maintenance of a facility: a. It can alter the performance of an installation but not the return on investment b. Does not alter the performance of an installation or the return on investment c. It can alter the performance of a facility and also the return on investment.
9 .- Geothermal energy is: a. A renewable energy that takes adNPVtage of the heat of the subsoil of the earth. b. A renewable energy that takes adNPVtage of the movement of tectonic plates c. None is correct
10 .- The reduction of the non-renewable primary energy consumption of a house can be done: a. Improving the insulation of the housing envelope b. Increasing the performance of the facilities c. Contributing a fraction of the energy through renewable energies d. All are correct

Unit 2: Economic profitability and energy efficiency

1.- All the measures of energy renovation in a house: a. Reduce the energy consumption of the house and are profitable b. They reduce the energy consumption of the house but may not be amortized over time. c. Profitability is not important since the main thing is the reduction of consumption.

2.- The minimum return required for an investment, either because the capital is borrowed and the cost of bank interest must be assumed, or because it could have been decided to invest in another product that generates more profitability, is called:

a. Internal rate of return
b. Opportunity cost
c. Both are correct

3.- The price of fuels is a parameter:

a. Easy to predict by natural evolution
b. Of difficult prognostication since it depends on political factors, commercial strategies, availability of natural resources
c. It can be rounded up with an annual increase of 3%

4.- The gross amortization period is:

a. A present-time indicator
b. A future time indicator
c. A little used indicator

5.- The gross amortization period is:

a. The quotient between the cost of the investment and the net annual savings of the implemented measure
b. The ratio between the net annual savings and the cost of the investment
c. Calculate the annual savings needed to amortize the investment in 10 years

6.- Taking into account a useful life of 20 years of an energy efficiency measure if the calculated gross amortization period is 5 years, the measure is a priori:

a. Profitable
b. Not profitable
c. Data is missing in order to make a decision

7.- The NPV and the IRR are:

a. Energy efficiency indicators
b. Profitability indicators of an investment
c. Quality indicators of the execution of a measure

8.- The RGB indicator indicates that the investment is profitable :

a. If its value is <0 as long as the calculated useful life is met
b. If its value is> 0 even if the calculated useful life is not met
c. If its value is> 0 as long as the calculated useful life is met

9 .- Which of the following values indicates a better profitability for the RBA indicator:

a. 2%
b. 3%
c. 4%

10 .- From the following economic indicators select the one that uses future estimation parameters:

a. Gross Amortization Period
b. Net Updated Value
c. Annual Gross Performance

11.- Assuming that the bank offers 5% for a 10-year fixed-term investment and an investment in energy rehabilitation gives a 3% annual return. What is the opportunity cost?

a. 5%
b. 3%
c. Neither

12.- With a simple interest of 10% per year for an investment of 10,000 €. After 3 years we will have:

a. € 13,000
b. € 11,000
c. € 13,310

13.- With a compound interest of 10% per year for an investment of 10,000 €, after 3 years, we will have:

a. € 13,000
b. € 11,000
c. € 13,310

14.- Which of the following B / C ratio values indicates a more profitable investment:

a. 0.98
b. 1
c. 1.05

15. - Which of the following expressions indicates a profitable investment:

a. NPV> 0

b. NPV = 0
c. NPV <0

16.- To calculate the NPV, it is necessary to know:

a. Annual cash flow
b. Opportunity cost
c. Initial investment
d. Time frame
e. All of them are correct

17.- The IRR is defined as the value defined as the discount rate that makes the NPV:

a. > 0
b. = 0
c. <0

18.- If the opportunity cost is 3% and the calculated IRR is 5%, the operation is:

a. Profitable
b. Not profitable

19.- The financial viability of a project:

a. It does not depend on the parameters of profitability
b. If the profitability indicators are positive, the operation is viable
c. None is correct

20 .- If the value of the NPV in year 15 of an investment with a useful life of 25 years is -3500 €, it indicates that:

a. The investment has already been profitable
b. The investment has not been profitable but will do so in the future
c. The investment has not been profitable and it is not known if it will do so in the future since the investment made is not known.

Unit 3 - EXAMPLES OF FEASIBILITY STUDIES, CALCULATION OF SAVINGS AND PERIOD OF AMORTIZATION OF THE ACTIONS

1.- The solution to reduce the energy consumption in non-renewable primary energy is made by :

a. Measures to reduce energy demand

b. Measures to increase the performance of the facilities c. Measures for the contribution of renewable energies d. All are correct
2.- The Unified Tool LIDER - CALENER (HULC) is: a. A Ministry of Industry software designed to calculate energy demand and energy certification of buildings. b. A software to calculate thermal loads. c. A software to calculate pipe diameters.
3.- For the calculation of the energy consumption, the performance of the heating and cooling machines that should be used is: a. Nominal performance b. Average seasonal yield c. None is correct
4.- The average seasonal performance in heating machines is usually called: a. COP b. SCOP c. EER d. SEER
5.- The average seasonal yield in refrigeration machines is usually called: a. COP b. SCOP c. EER d. SEER
6.- Taking into account a useful life of 20 years of an energy efficiency measure if the calculated gross amortization period is 5 years, the measure is a priori: a. Profitable b. Not profitable c. Data is missing in order to make a decision.
7.- The NPV and the IRR are: a. Energy efficiency indicators b. Profitability indicators of an investment c. Quality indicators of the execution of a measure
8.- Which of the following energy efficiency measures is based on the reduction of energy demand :

a. Improvement of the thermal insulation of enclosures
b. Replacement of condensing or low temperature boilers instead of conventional
c. Generation of electrical energy through photovoltaic panels

9 .- Which of the following energy efficiency measures is based on increasing the performance of the facilities:

a. Improvement of the thermal behavior of doors and windows
b. Replacing conventional lamps with LED
c. Change of fuel to biomass

10 .- Which of the following energy efficiency measures is based on the contribution of renewable energies:

a. Improvement of the behavior of thermal bridges.
b. Use of heat recovery units or free cooling systems.
c. Use of geothermal or aerothermal heat pumps.

11. Which of the following energy efficiency measures reduce consumption of non - renewable primary energy

a. Replacement of condensing or low temperature boilers instead of conventional
b. Use of geothermal or aerothermal heat pumps.
c. Improvement of the thermal behavior of doors and windows
d. Replacing conventional lamps with LED
e. Change of fuel to biomass
f. All are correct

1 2 .- A Joule effect heater with an automatic regulation has a seasonal average yield of:

a. 1
b. 0.97
c. 0.92

13 .- The future evolution of fuel prices depends on:

a. Offer and demand
b. Political strategy
c. International juncture
d. All are correct

1 4 .- The amount of fuel needed is calculated:

a. Dividing the energy needed by the fuel PCI

b. Multiplying the energy needed by the fuel PCI c. None is correct
1 5 .- The PCI is: a. Indicated heat power b. Lower calorific value c. Higher calorific power
16.- Which of the following parameters should be future estimates for the calculation of the NPV and the IRR. a. Annual cash flow b. Opportunity cost c. Initial investment d. Price of fuels e. B and D are correct f. B and C are correct
17.- The average seasonal yield of a condensing boiler: a. It always has to be less than 100% b. It can be more than 100% c. It usually reaches 93% highs
18.- If the opportunity cost is 3% and the calculated IRR is 5%, the operation is: a. Profitable b. Not profitable
19.- Biomass boilers: a. They have low combustion efficiency but it is compensated because their contribution is considered as renewable energy b. They have more performance than gas condensing boilers. c. Renewable energies are not considered since they generate CO2
20 .- If the SEER of a refrigeration machine is 6, it corresponds an energetic letter of: a. B b. A c. A +

ANSWERS

Unit 1

1. a
2. c
3. a
4. a
5. a
6. b
7. b
8. c
9. a
10. d

Unit 2

1. b
2. c
3. b
4. a
5. a
6. a
7. b
8. c
9. c
10. b
11. a
12. a
13. c
14. c
15. a
16. e
17. b
18. a
19. a
20. c

Unit 3

1. d
2. a
3. b
4. b
5. d
6. a
7. b
8. a
9. b
10. c

11. f
12. a
13. d
14. a
15. b
16. a
17. b
18. a
19. a
20. c