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Environmental Projects and Consulting

CustomLCA

Aerogel LCA High Performance Insulating Plaster

LCA of Fixit 222 Aerogel High Performance Insulating Plaster from Fixit AG

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Summary

Fixit AG, in association with EMPA, has developed the first high performance insulating plaster, Fixit 222, which, due to the addition of Aerogel, provides twice the insulating value of currently marketed brands of plaster. This means that old buildings, and historical and heritage-protected structures, can now be renovated for energy saving purposes, without infringing the quality of the architectural detail of the walls.

The goal of this LCA is to calculate the environmental footprint for the whole life cycle of Fixit 222 High Performance Insulating Plaster and to provide answers to related questions from customers. To be able to draw conclusions about the effective environmental benefits of the insulation, the grey energy of Fixit 222 was compared to the benefits deriving from energy savings for heating a building.

This study is based broadly on the guidelines of the ISO 14040 standard; the procedure meets the principal requirements of these standards. At certain points, such as the application of the total aggregate method, this study exceeds the standard's prescriptions.

Table 1 lists the environmental impacts resulting from the LCA calculations:

Table 1: Impacts of 1 kg Fixit 222 Aerogel High Performance Insulating Plaster

Impact Category	1 kg Fixit 222	Unit
Global Warming Potential	4.27 ± 10 %	kg CO_2 equiv.
Cumulated Energy Demand	66.9 ± 12 %	MJ equiv.
Acidification Potential	0.0137 ± 18 %	mol H+ equiv.
Eutrophication Potential Terrestrial	0.0313 ± 16 %	mol N equiv.
Eutrophication Potential Freshwater	0.00018 ± 52 %	kg P equiv.
Eutrophication Potential Marine	0.00310 ± 14 %	kg N equiv.
Ozone Creation Potential	0.00885 ± 16 %	kg NMVOC equiv.

The LCA data was weighted according to the Ecological Scarcity Method 2013, and a relevancy analysis shows that the light-weight additives contribute 85 % to the environmental footprint.

With additional grey energy calculations, combined with energy savings due to insulation benefits for a standard wall system, calculations for a 5 cm thick layer of Fixit 222 result in an energy payback time of 2.9 years. Over the assumed serviceable life of 40 years, the cumulative net energy saving amounts to 2,400 kWh/m², or around 240 litres of heating oil per m² wall surface area.

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1 Background and Mandate

A building erected in the middle of 1975 required approximately 22 litres of heating oil per heated square metre. In 2005, the same heating could be achieved with 7–9 litres of heating oil (Mühlethaler and Jordi, 2011). This consumption can be reduced even further, and the 2008 Cantonal Model Regulations for the Energy Sector (Konferenz Kantonaler Energiedirektoren, 2008) currently set the maximum consumption level at 4.8 litres heating oil equivalent (incl. hot water). These figures demonstrate that much has happened in the field of heating insulation of houses in the past 30 years, and that for older buildings there is a large catch-up demand. When one considers that space heating accounted for 33 % of the energy consumption in Switzerland in 2013 (not including district, environmental and solar heating) (Kemmler et al., 2013) then it quickly becomes apparent that there is a high savings potential in Switzerland in the field of energy renovation.

It is precisely with old and listed buildings that a standard external insulation with insulating panels is not possible. Either this would ruin the overall look, which is the purpose of the buildings' protection, or corners, edges and rounded segments make the use of insulating panels too difficult. In these cases, the use of insulating plaster for external and/or internal insulation is required. A conventional plaster, however, compared to standard insulating panels, has the disadvantage that the thermal insulating value for the same layer thickness is significantly inferior.

Fixit AG, in association with EMPA, has developed the first High Performance Insulating Plaster, which, due to the use of the Aerogel insulating additive, provides twice the insulating performance as other market-available plasters. Old buildings, and buildings or monuments under historical and heritage protection classification, can therefore be renovated for energy saving, without losing any of the architectural details of the walls.

In order to be able to answer questions related to the environmental impact of Fixit 222 High Performance Insulating Plaster, Carbotech AG was commissioned to analyse the environmental footprint[1] of the product through an LCA, life cycle assessment.

In order to be able to make statements about the effective environmental impacts of the plaster, the primary energy consumption during production, use and disposal - i.e. the grey energy - of the plaster, was compared to the energy saved whilst heating the building.

It needs to be mentioned at this point that Carbotech AG has no interests in the involved companies, nor is it in any way dependent on them, or vice-versa. The conditions for the conduct of a neutral LCA are therefore satisfied. For confidentiality reasons, the documented level of detail, and with it the transparency, is limited.

[1] The environmental footprint is a calculated or otherwise determined value for the environmental impact of a product (or other system) over its whole life cycle.

2 Method

An LCA is the most comprehensive and informative method for assessing the environmental impact of products and systems. For this reason, this method was used to determine the environmental impact of the plaster in question.
This chapter describes the method used, the procedure, the data employed, and any underlying assumptions.

2.1 General Description of Life Cycle Assessing

The LCA (Life Cycle Assessment) is a method for calculating and assessing the impacts of human activities on the environment, from which optimizing potential can be derived. Due to the complexity of nature and the global economic system, it is not sufficient to consider only individual problematic substances or local effects. Due to the demand for a comprehensive assessment, the methodology must meet the following requirements:

- account as broadly as possible for the different types of environment impacts
- cover the entire life cycle
- quantification of the environmental impacts
- assessment of the various impacts as a basis for decision-making
- gain scientific supporting evidence for greater reliability and acceptance.

The LCA is the method which today best fulfils these requirements. The results of the LCA can be used:

- as decision-making support for various alternatives
- to determine the relevant impacts
- in strategic planning for the calculation of optimizing potential
- for the calculation of major influencing factors
- in the evaluation of measures
- to derive recommendations for action.

2.2 LCA Procedures

After the questions and system to be investigated have been defined, the goods, materials and energy flows, as well as the resource demands, are determined. Finally, the impacts on the environment are determined by means of chosen indicators, which describe these impacts. With the aim of reducing the results to a single figure, and thereby make the interpretation possible, or at least easier, the assessment of the various environmental impacts can be weighted accordingly.

As described in ISO 14040 and ISO 14044 (ISO 14040, 2006; ISO 14044, 2006) an LCA involves the following steps:

- Definition of goal, scope and system boundaries (framework conditions)
- Determination of the relevant material and energy flows, as wells as resource demands (life cycle inventory)
- Calculation of the environmental impacts (impact assessment)
- Interpretation of the environmental impacts on the basis of the specified goal (impact analysis)
- Preparation of recommendations for measures (optimization)

As Figure 1 shows, this is not a linear process, rather an interactive fact-finding and optimization process.

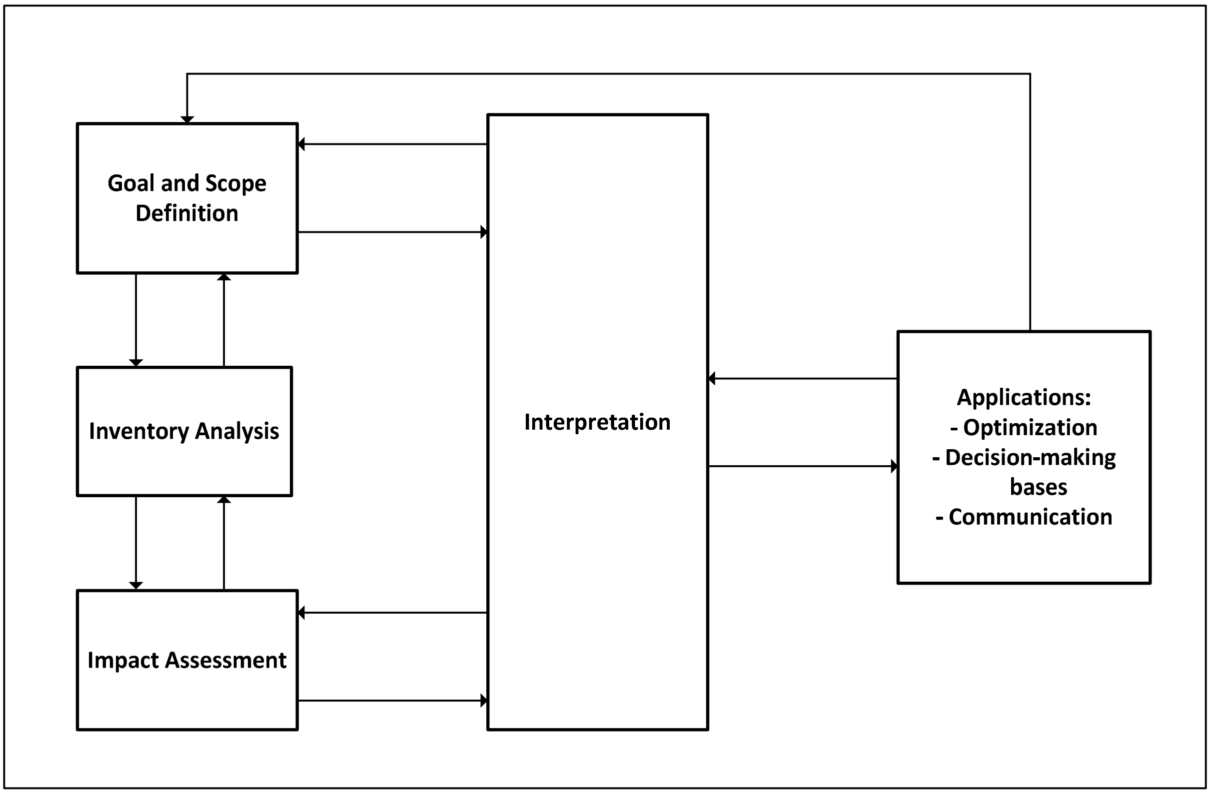

Figure 1: Steps of an LCA in accordance ISO 14'040 ff.

This study is based primarily on the ISO 14040 standard. The procedure corresponds in the main points to its specifications, but in certain points, such as the use of total aggregate methods, this study goes beyond the standard's prescriptions.

2.3 Goal

As mentioned in Chapter 1, this LCA has the aim of calculating the environmental footprint over the entire life cycle of Fixit 222 High Performance Insulating Plaster. In addition, the effective environmental benefit of the plaster will be assessed, for which the primary energy consumption during production, application and disposal of the plaster, is balanced against the reduction in environmental footprint due to building heating energy savings.

2.4 Functional Unit

1 kg Fixit 222 is set as the functional unit.

2.5 System Boundaries

The LCA considers the potential environmental impacts of a product over its entire life cycle ("from the cradle to the grave"). Its scope encompasses from the extraction of raw materials, through processing to packaged goods, packaging, transport, use and onwards to disposal. For all of these phases, all of the environmentally related processes are determined and evaluated as far as possible.

2.5.1 Life Cycle System Boundary

The life cycle system boundary for this LCA covers all related emissions and resource consumption during production, use and disposal of the plaster. These cover the following parameters (see also Figure 2):

- raw materials
- additives
- energy consumption
- transport
- disposal

The results per functional unit are then calculated and presented for the entire life cycle, up to and including disposal. The use phase, which has the aim of saving on heating energy, is dependent on local conditions in the plastered buildings, and consequently is not included in the LCA results (in accordance with the Ecoinvent Quality Guidelines (Version 2.2)). As extension of this LCA, a calculation of the energy payback time of the grey energy is given in a separate chapter (see Chapter 6).

Not taken into account are the dust accumulations during production and application of the High Performance Insulating Plaster Fixit 222, which, if workplace regulations are maintained, present no hazard for human health. In addition, the costs for removal of the plaster at the end of its serviceable life are not calculated, as they are considered insignificantly small. In the case of a complete demolition of a building, the additional costs are practically zero.

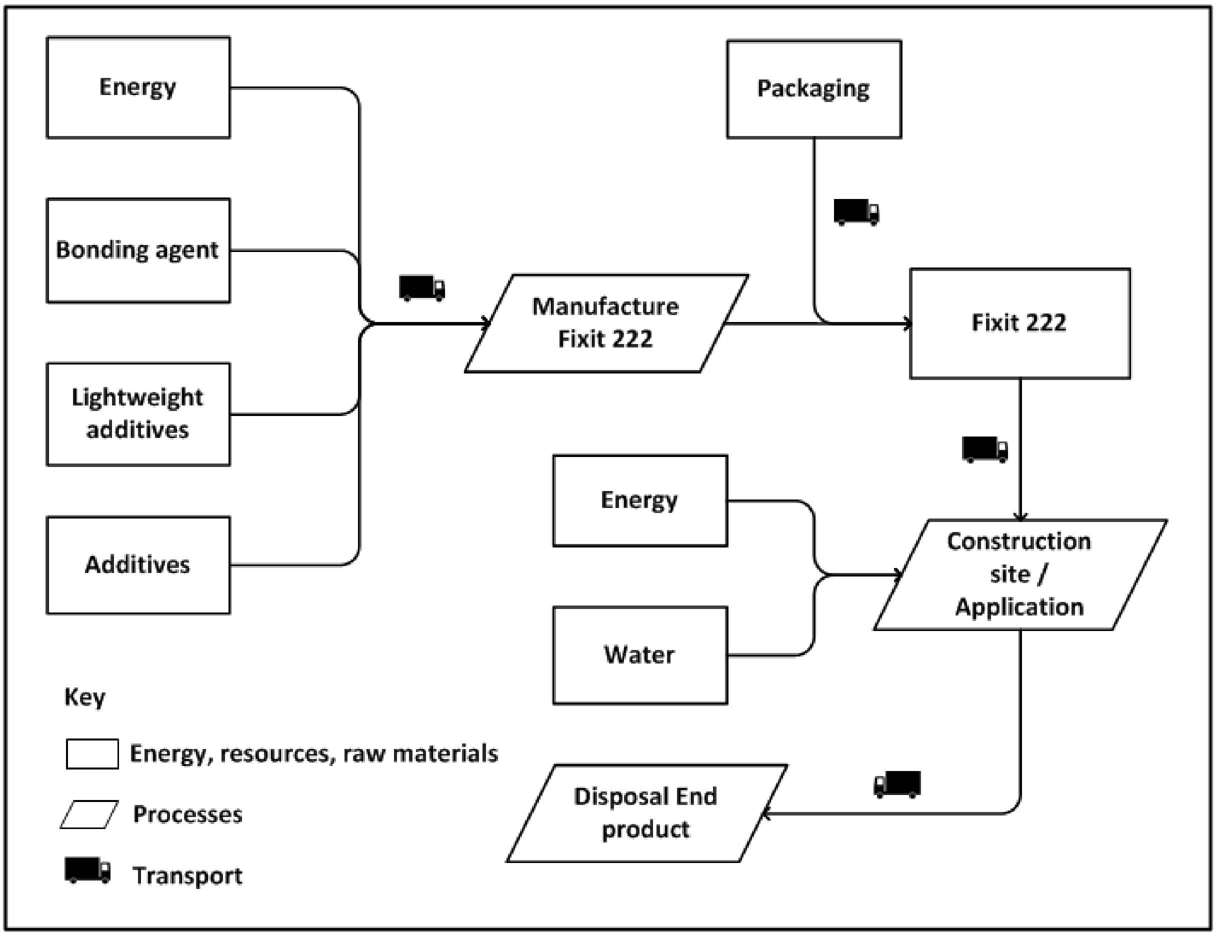

Figure 2: Life Cycle System Boundary (Scope) for the Fixit 222 LCA

2.5.2 Temporal System Boundary

The specific data obtained from the plaster manufacturer, and the producer of the Aerogel (as primary pre-process), reflects the production situation in 2013. The inventory data is therefore up-to-date for the life cycle, and meets the corresponding quality requirements. For less important background data (process data, life cycle inventory), the LCA standard database Ecoinvent V2.2 (ecoinvent, 2010) was used.

2.5.3 Spatial System Boundary

The plaster is manufactured in Switzerland. As power mix for the manufacture phase, the corresponding Swiss supply-mix was used. For background data (life cycle inventories, specific process data), as far as possible the local conditions of the corresponding production location, state or international energy networks were taken into account.

2.5.4 Allocations

For the calculations of the environmental impacts of Fixit 222, no allocations were required.

3 Inventory Analysis

3.1 Data Collection and System Modelling

The standard data from Ecoinvent V2.2 was used as the basis for data for less relevant, upstream processes. The composition of Fixit 222 is confidential, so the data raised for the LCA are not published in this study report.

3.1.1 Manufacture

The data was obtained directly from the manufacturer, Fixit AG. The first rough assessment of the environmental impacts showed that the lightweight additive Aerogel made by far the greatest contribution to these results. For this reason, the Aerogel production data was also obtained directly from the manufacturer, and used in the calculations. This process data is also confidential, and consequently cannot be published in this study. According to the manufacturer's information, there are no direct pollutant emissions during the manufacture of the plaster. The necessary infrastructure was estimated. Since Aerogel is the only quantitatively relevant ingredient limited by its volume rather than its weight, the transport data was obtained directly from the suppliers. For all other transport, the Ecoinvent dataset with standard loads was used.

3.1.2 Application

For the mixing and application of the plaster, figures regarding water use and energy consumption were obtained from the plaster manufacturer. According to the manufacturer's information, there are no direct pollutant emissions during the application phase.

Table 2: Energy and raw materials for the application of 1 kg Fixit 222 Aerogel High Performance Insulating Plaster
Raw materials, energy data, assumptions and process applications

	Description	Quantity	Unit	Assumption/comments	Ecoinvent dataset description
Energy	Electrical power	0.039	kWh	Power consumption of plaster-making machine according to Fixit data	Electricity, low voltage, at grid/CH
Water	Water	1.25	kg	Water consumption during mixing of the plaster according to Fixit data	Tap water, at user/RER

For the transport of Fixit 222 from the manufacturer to the construction site, a standard transport model on the basis of the method description in Ecoinvent was used (Frischknecht et al., 2007).

3.1.3 Use

Once applied, the plaster requires no further energy, raw materials or other supplies. A lime plaster, however, absorbs carbon dioxide from the air during its long hardening process (carbonisation), explained in more detail in the following.

The first stage of the manufacture of hydrated lime (component of the plaster) is the burning of calcium carbonate ($CaCO_3$), which produces quicklime by releasing CO_2. The subsequent "slaking" in water produces slaked lime, or calcium hydroxide. This is added to the plaster as bonding agent, and the subsequent bonding process reabsorbs CO_2 (see Figure 3). This absorption of CO_2 from the air therefore reduces the CO_2 footprint of the Fixit 222 plaster.

Since the bonding of hydrated lime is a very slow process, the delayed effect of the CO_2 absorption is reported separately.

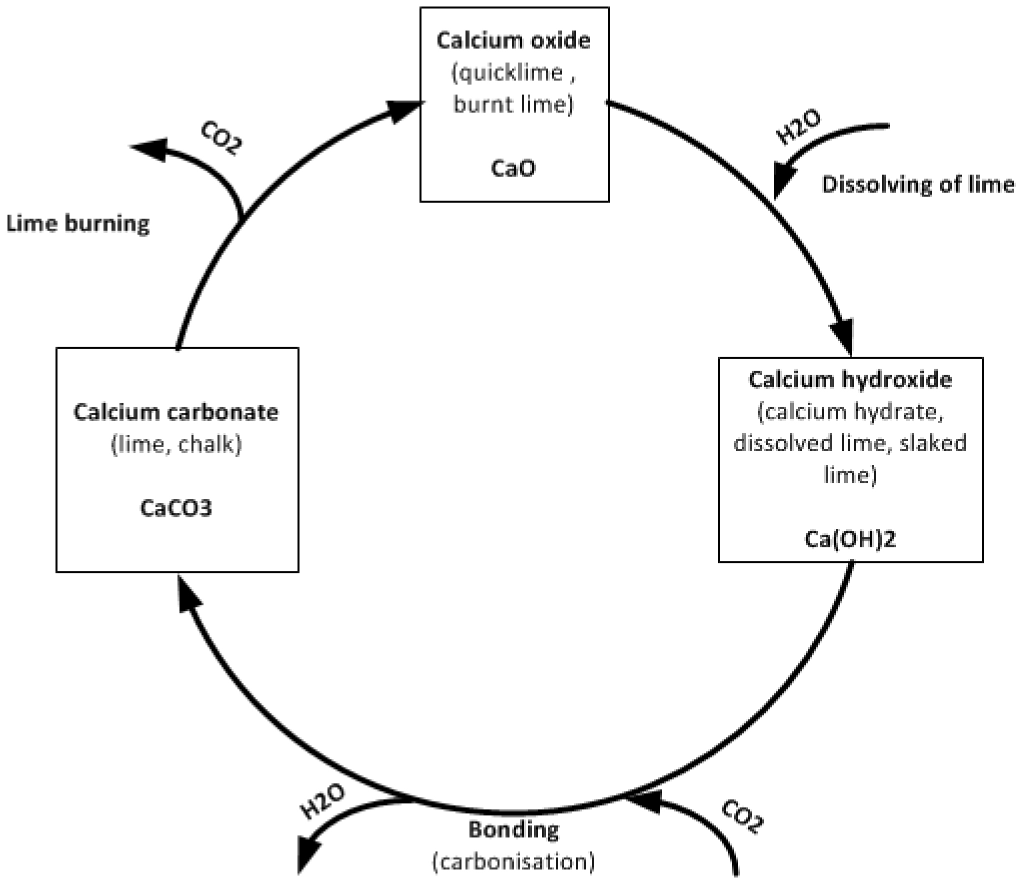

Figure 3: Calcium (lime) cycle

As mentioned previously in the System Boundaries chapter, the savings of primary energy for heating are not included in the calculations for the LCA results.

3.1.4 Disposal

For a reclamation or re-use of plaster with lightweight additive Aerogel, there is no data from previous experience, since the product is new to the market. A rough assessment was made on the basis of a "Worst-Case Scenario", that all of the plaster is disposed of in an inert material landfill. It reveals that the disposal contributes insignificantly to the environmental footprint. For this reason, the described "Worst-Case Scenario" was retained for the LCA calculations.

Table 3: Process attribution for the disposal of 1 kg Fixit 222 Aerogel High Performance Insulating Plaster
Raw materials, energy data, assumptions and processes employed

	Description	Quantity	Unit	Assumptions/Comments	Ecoinvent Dataset description
Disposal	Inert material disposal	1.1	kg	Dry plaster still contains approx. 10 % bonded water	Disposal, inert waste, 5 % water, in inert material landfill /CH

3.2 Calculation of the Life Cycle Inventory

The Life Cycle Inventory was calculated using the LCA Software SimaPro 8 (PRé Consultants, 2014) and used in the Impact Assessment.

4 Impact Assessment

In this stage, the Life Cycle Inventory was analysed for environmental impacts. This impact analysis was conducted as follows:

- Classification (sub-division according to impact)
  The materials were grouped according to their various impacts on the environment.
- Characterisation (environmental impact calculation): the individual substances were weighted in accordance with their potential to do harm compared to a reference substance. From this was derived a damage potential for a specific environmental impact.

A number of different environmental impacts were selected according to the investigated processes and stated goal. For the purposes of this study, the following impacts were calculated:

- Global Warming Potential (GWP)
  Impact on the climate due to emissions from climate-influencing substances, such as carbon dioxide (CO_2), laughing gas (N_2O) and methane (CH_4). These impacts were calculated according to IPCC for 2013, and included in this report (IPCC, 2014).
- Cumulated Energy Demand (CED)
  Grey energy or consumption of renewable and non-renewable energy resources. The calculation was done according to the method described in Ecoinvent Report No. 3 (Hischier et al., 2010).
- Acidification Potential
  Contribution to acidification of ground and water, from compounds such as nitrogen oxides and sulphur dioxide. The calculation was done on the basis of the Accumulated Exceedance Method (Posch et al., 2008; Seppälä et al., 2006).

- Eutrophication (over-fertilisation)
  Changes to the nutrient balance in soil and water, due to the introduction of compounds which contain nitrogen and phosphorous. The calculation of soil eutrophication was done on the basis of the Accumulated Exceedance Method (Posch et al., 2008; Seppälä et al., 2006). The calculation of water eutrophication was done on the basis of the EUTREND Model, as it is implemented in the ReCIPe method (Struijs et al., 2009).
- Ozone Formation Potential
  Contribution to the development of ozone (photosmog), due to emissions of compounds such as hydrocarbons and nitrous oxides (NO_x). The calculation was done on the basis of the ReCIPe implemented method LOTOS_EUROS (van Zelm et al., 2008).

For most of the selected impact assessments, the recommended calculation method of the JRC (European Commission-Joint Research Centre, 2011) was used. Only the calculation of the cumulated energy consumption is done according to the method described in Ecoinvent Report No. 3 (Hischier et al., 2010) since the JRC does not provide any recommendations for this.

4.1 Impact Assessment Results

In this step, the life cycle inventory is assessed with regards the environmental impacts. The results are reported for 1 kg Fixit 222.
The last column of the table gives the percentage the process (manufacture, application, etc.) in each case contributes to the overall product balance in the respective impact category. For simplicity, the contributions are given only as a percentage of the total, without considering the carbonisation in the use phase.
All results are allocated an uncertainty range, to take into account uncertainties regarding the data and the calculated quantities, as well as inherent uncertainty in the methods used. The uncertainty of the results (one standard deviation) in each case is calculated by Monte Carlo Analysis using the LCA-Software SimaPro 8 (PRé Consultants, 2014).

4.1.1 Manufacture

In Table 4 are listed the results for the manufacture of the Fixit 222 plaster, including raw materials and pre-processing.

Table 4: Results of the Impact Assessment for Fixit 222 Aerogel High Performance Insulating Plaster for the manufacture life cycle phase

Impact Category	Unit	1 kg Fixit 222	Percent of the total product impact
Global Warming Potential	kg CO_2 equiv.	4.25 ± 11 %	99.5 %
Cumulated Energy Demand	MJ equiv.	66.1 ± 13 %	98.8 %
Acidification Potential	mol H+ equiv.	0.0135 ± 20 %	99.0 %
Eutrophication Potential Terrestrial	mol N equiv.	0.0308 ±19 %	98.3 %
Eutrophication Potential Freshwater	kg P equiv.	0.00018 ± 53 %	99.4 %
Eutrophication Potential Marine	kg N equiv.	0.00305 ± 16 %	98.5 %
Ozone Creation Potential	kg NMVOC equiv.	0.00870 ± 19 %	98.3 %

The manufacture of Fixit 222 High Performance Insulating Plaster, with over 98 % of the total product impact, is by far the most important process for all considered impact categories.

4.1.2 Application

The results for the application of the Fixit 222 plaster including raw materials and pre-processing are listed in Table 5

Table 5: Results of the Impact Assessment for Fixit 222 Aerogel High Performance Insulating Plaster for the application life cycle phase

Impact Category	Unit	1 kg Fixit 222	Percent of total product impact
Global Warming Potential	kg CO_2 equiv.	0.0096 ± 18 %	0.2 %
Cumulated Energy Demand	MJ equiv.	0.565 ± 18 %	0.8 %
Acidification Potential	mol H+ equiv.	0.0000542 ± 23 %	0.4 %
Eutrophication Potential Terrestrial	mol N equiv.	0.00016 ± 34 %	0.5 %
Eutrophication Potential Freshwater	kg P equiv.	0.00000091 ± 57 %	0.5 %
Eutrophication Potential Marine	kg N equiv.	0.000015 ± 33 %	0.5 %
Ozone Creation Potential	kg NMVOC equiv.	0.000046 ± 33 %	0.5 %

The application of Fixit 222 High Performance Insulating Plaster, at less than 1 % of the total product impact, is insignificant for all considered impact categories.

4.1.3 Use

Once applied, the plaster requires neither energy, raw materials nor other materials during the use phase, and therefore remains without influence on the impact assessment. Since $CO_2$is absorbed from the air during the bonding phase (carbonisation), the Global Warming Potential reduces slightly. The results are summarised in Table 6.

Table 6: Results of the Impact Assessment for Fixit 222 Aerogel High Performance Insulating Plaster for the use life cycle phase

Impact Category	Unit	1 kg Fixit 222 without carbonisation	1 kg Fixit 222 with carbonisation	Percent of total product impact
Global Warming Potential	kg CO_2 equiv.	0	-0.1 ±14%	-2.3 %
Cumulated Energy Demand	MJ equiv.	0	0	0.0 %
Acidification Potential	mol H+ equiv.	0	0	0.0 %
Eutrophication Potential Terrestrial	mol N equiv.	0	0	0.0 %
Eutrophication Potential Freshwater	kg P equiv.	0	0	0.0 %
Eutrophication Potential Marine	kg N equiv.	0	0	0.0 %
Ozone Creation Potential	kg NMVOC equiv.	0	0	0.0 %

During the use phase of Fixit 222 High Performance Insulating Plaster, there is a slight reduction in Global Warming Potential.

4.1.4 Disposal

The results for the disposal of Fixit 222 plaster, including raw materials and pre-processing, are summarised in Table 7.

Table 7: Results for the Impact Assessment for Fixit 222 Aerogel High Performance Insulating Plaster for the disposal life cycle phase

Impact Category	Unit	1 kg Fixit 222	Percent of total product impact
Global Warming Potential	kg CO_2 equiv.	0.010 ± 30 %	0.2 %
Cumulated Energy Demand	MJ equiv.	0.26 ± 35 %	0.4 %
Acidification Potential	mol H+ equiv.	0.000080 ± 31 %	0.6 %
Eutrophication Potential Terrestrial	mol N equiv.	0.00037 ± 32 %	1.2 %
Eutrophication Potential Freshwater	kg P equiv.	0.00000012 ± 59 %	0.1 %
Eutrophication Potential Marine	kg N equiv.	0.000033 ± 32 %	1.1 %
Ozone Creation Potential	kg NMVOC equiv.	0.00011 ± 31 %	1.2 %

The disposal of Fixit 222 High Performance Insulating Plaster, at less than 1.5 % of the total product impact, is not significant for all considered impact categories.

4.1.5 Total Impact Assessment for all Categories

In Table 8 are summarised the results for the Fixit 222 plaster from cradle to grave, with and without carbonisation (absorption of CO_2 during bonding).

Table 8: Results of the Impact Assessment for Fixit 222 Aerogel High Performance Insulating Plaster Total

Impact Category	Unit	1 kg Fixit 222	
		Excl. Carb.*	**Incl. Carb.***
Global Warming Potential	kg CO_2 equiv.	4.27 ± 10 %	4.17 ± 10 %
Cumulated Energy Demand	MJ equiv.	66.9 ± 12 %	66.9 ± 12 %
Acidification Potential	mol H+ equiv.	0.0137 ± 18 %	0.0137 ± 18 %
Eutrophication Potential Terrestrial	mol N equiv.	0.0313 ± 16 %	0.0313 ± 16 %
Eutrophication Potential Freshwater	kg P equiv.	0.00018 ± 52 %	0.00018 ± 52 %
Eutrophication Potential Marine	kg N equiv.	0.00310 ±14 %	0.00310 ± 14 %
Ozone Creation Potential	kg NMVOC equiv.	0.00885± 16 %	0.00885 ± 16 %

*Carb = carbonisation (absorption of CO_2 during bonding)

5 Interpretation

The Impact Assessment results concern the collation of different indicators, each of which describes one aspect of the environmental impacts (Figure 4). In order to obtain a well-founded decision-making basis, the different impacts can be weighted, and summed to a single figure. For this purpose, there are a number of methods.

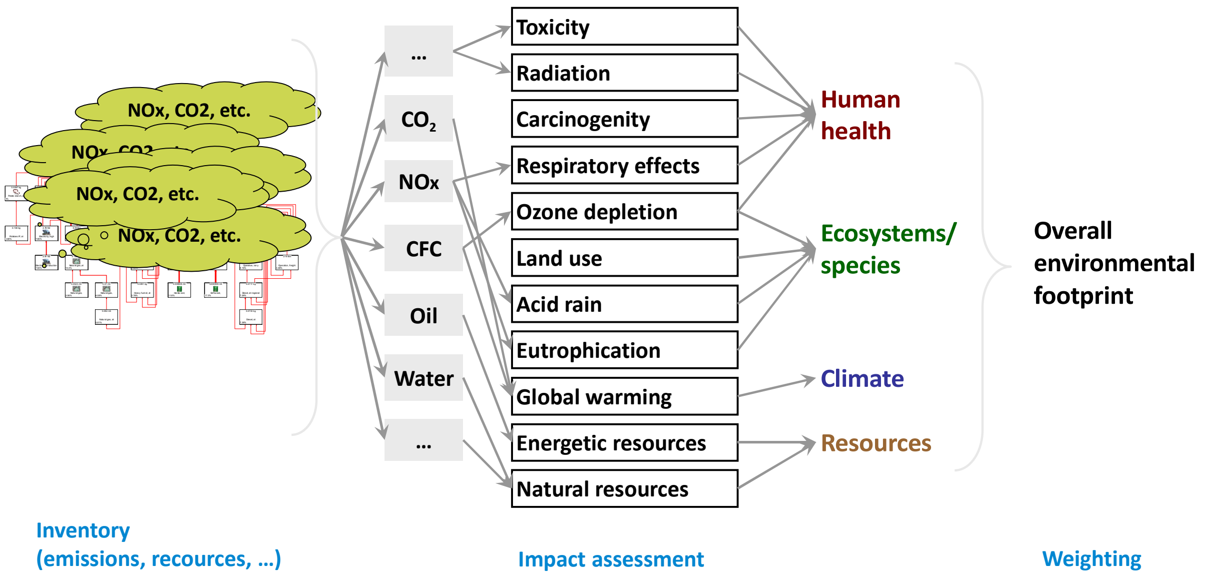

Figure 4: Sequence of the LCA Impact Analysis

This study utilises the Ecological Scarcity Method 2013 (Frischknecht R. and Büsser Knöpfel S., 2013). The analysis by means of the Ecological Scarcity Method was developed in association with the Swiss Federal Office for the Environment, and is a well-established method in Switzerland. This method was chosen, since it allows the analysis to take into account both the environmental situation and the environmental targets of Switzerland. Although this method reflects Swiss environmental policies, it has a high level of acceptance internationally. The results are expressed in eco-points (EP).

5.1.1 Environmental Footprint

The environmental footprint of Fixit 222 from manufacture to disposal (cradle to grave), based on the Ecological Scarcity Method 2013, is summarised in Table 9.

Table 9: Environmental footprint results for Fixit 222 Aerogel High Performance Insulating Plaster

Life Cycle Phase	Unit	1 kg Fixit 222	Percent of total product impact
Manufacture	EP	3'676 ± 14 %	98.9 %
Application	EP	22 ± 16 %	0.6 %
Use without carbonisation	EP	0	0.0 %
Use with carbonisation	EP	-46 ± 14 %	-1.2 %
Disposal	EP	17 ± 30 %	0.5 %
Total with carbonisation	**EP**	**3'669 ± 12 %**	**98.8 %**
Total without carbonisation	**EP**	**3'715 ± 12%**	**100 %**

As the impact assessment clearly shows, the by far greatest contribution to the environmental impact arises during the manufacture of Fixit 222 (see also Figure 5). The application and disposal life cycle phases contribute less than 1 % each to the overall environmental footprint. If carbonisation is included in the calculation, the overall environmental footprint reduces to a little more than 1 %.

5.1.2 Analysis of the Sources and Causes of Environmental Impacts

In Figure 5, the sources of environmental impact from Manufacture, Application and Disposal are presented for one kilogram Fixit 222 Aerogel High Performance Insulating Plaster in a flow diagram. Around 85 % of the environmental impact is caused by the lightweight additive. A further almost 10 % of the environmental impact is caused by the bonding agent. All other inputs and processes play a minor role.

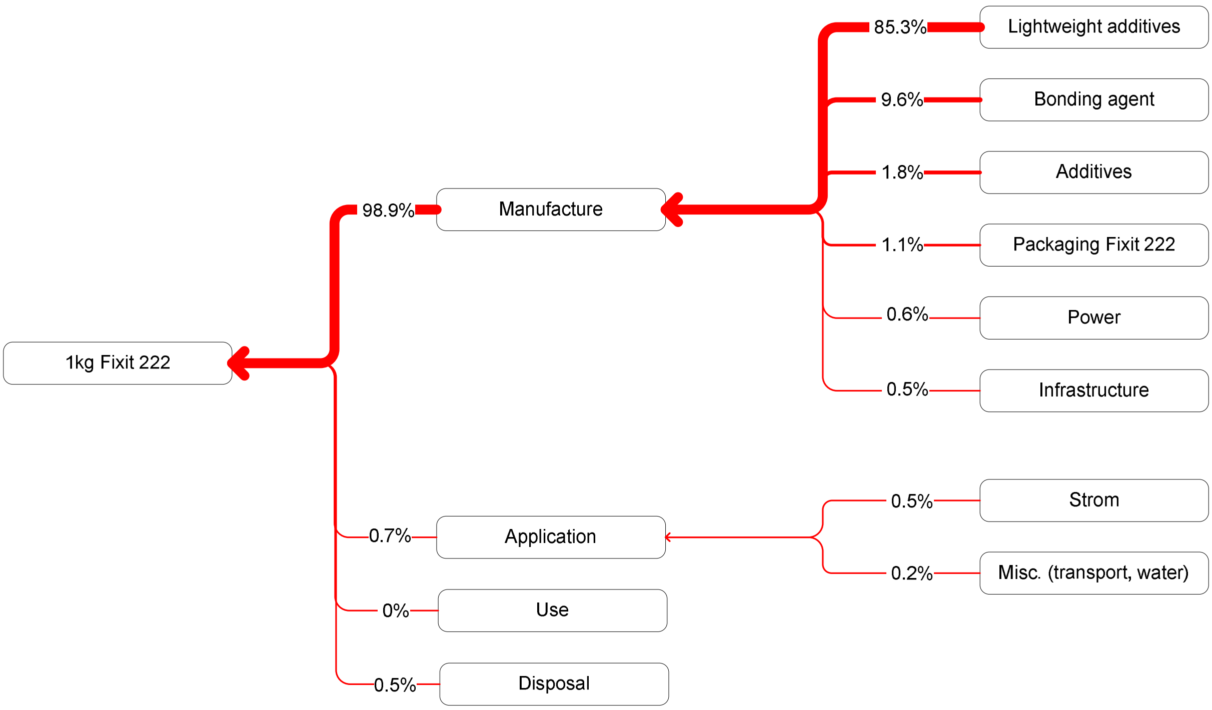

Figure 5: Analysis of sources of environmental impacts for Fixit 222 Aerogel High Performance Insulating Plaster
The environmental impact was calculated using the Ecological Scarcity Method 2013.

Looking at the causes of environmental impact (see Figure 6), it becomes clear that approximately 65 % of the environmental impact is due to the principal air emissions from the burning process (CO_2, NO_x, SO_2, particles). Around 5 % of the environmental impact is due to radioactive waste during power generation. All other resource usage and emissions contribute less than 5 % to the total environmental impact.
Neither presentation of the results includes the slight CO_2-reducing effect of the carbonisation, since this makes effectively no change to the results (approx. 1 % reduction, see Table 9).

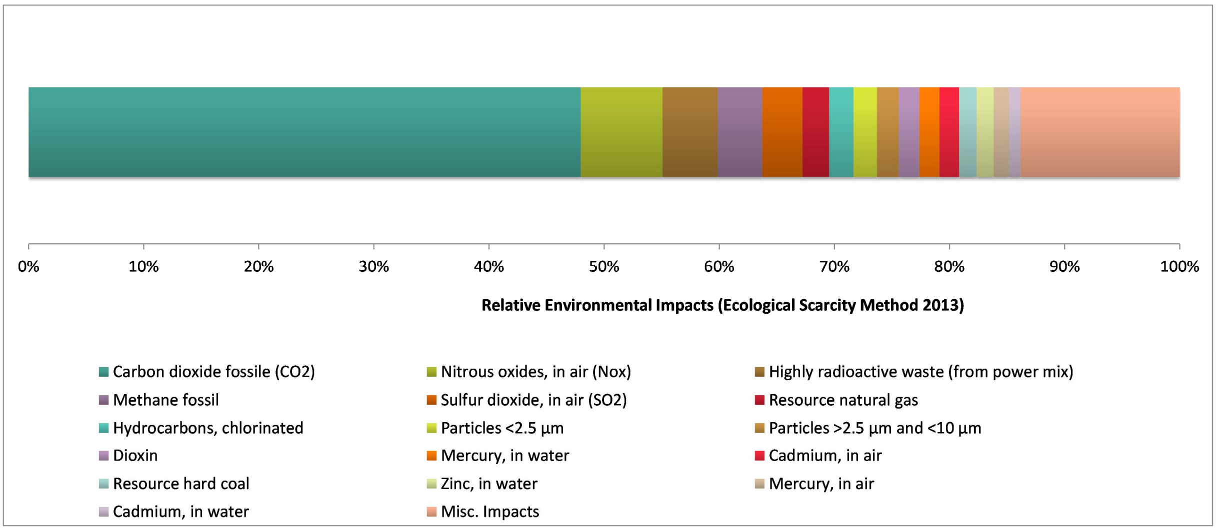

Figure 6: Causes of environmental footprint in the LCA for 1 kg Fixit 222 Aerogel High Performance Insulating Plaster
The environmental footprint was calculated using the Ecological Scarcity Method 2013. Causes with less than 1 % effect are grouped together under "Misc. impacts".

6 Energy Payback Time

The energy payback time extends the environmental assessment beyond the limits of the above calculated LCA, since it brings the insulating benefit - and with it the corresponding primary energy savings - into relation with the grey energy of the plaster.
Since the plaster is used mainly in old buildings as external plastering, for the purposes of the calculation of the added insulation value of Fixit 222 Aerogel High Performance Insulating Plaster, i.e. the energy savings from improved insulation, a layer thickness of 5 cm plaster for a square metre of brick wall was used. This is a commonly used plaster thickness used in renovations of old buildings.
The insulating benefit is calculated and recorded as saved primary energy per year in MJ/m² plastered wall surface. The dry pre-application density of Fixit 222 is 220 kg/m³. The density of the dry plaster after application is about 200 kg/m³. This means that approximately 10% of the original mass is replaced by bonded water. 10 kg Fixit 222 is therefore needed per square metre for a 5 cm thick plaster layer.
In addition, the savings in primary energy due to the insulating plaster over the assumed serviceable life of 40 years are given.

6.1 Grey Energy Calculation

At a density of 200 kg/m³, a 5 cm thick insulating layer requires 10 kg Fixit 222 plaster per square metre. From this, the corresponding grey energy can be simply calculated as the cumulated energy cost of 66.9 MJ/kg (resp. 18.6 kWh/kg) for Fixit 222. Table 10 shows the basis and results for the calculations of the grey energy.

Table 10: Grey energy results for Fixit 222

	Thermal conductivity Lambda W/mK	Grey energy (primary energy use) kWh/kg Fixit 222	Thickness Fixit 222 layer kg/m³	Layer thickness in metres	Grey energy (primary energy use) per 5 cm Plaster/m² in kWh
Fixit 222	0.028	18.6	200	0.05	186

6.2 Calculation of Insulation Benefits

In order to be able to calculate the benefits of the added insulation, a standard wall system must be defined. For this purpose, an uninsulated, unplastered brick wall, 29cm thick, with a U-value of 1.2 W/(m²K), is compared with a similar wall with a 5 cm thick layer of Fixit 222 Aerogel High Performance Insulating Plaster. The result is an annual primary energy saving due to the insulation of 65 kWh/m². The detailed calculation basis and results are summarised in Table 11.

Table 11: Savings of primary energy through 5 cm Fixit 222 on a brick wall with 3,300 heating-degree-days

	Thermal conductivity Lambda W/mK	Layer thickness in metres	U-value W/m²K	Energy consumption kWh/m²/year	Energy savings per year in kWh/m²
Standard wall	0.44	0.29	1.2	95	n. a.
Standard wall with 5 cm Fixit 222/m²	0.14	0.34	0.38	30	65

6.3 Results

The function of cumulated net saving of primary energy which results from these calculations is graphed in Figure 7 and Figure 8. The intersection of the line with the x-axis indicates an energy payback time for the Fixit 222 grey energy of approximately 2.9 years, while the intersection of the straight line with the y-axis shows the grey energy level (186 kWh per 5 cm plaster/m²)

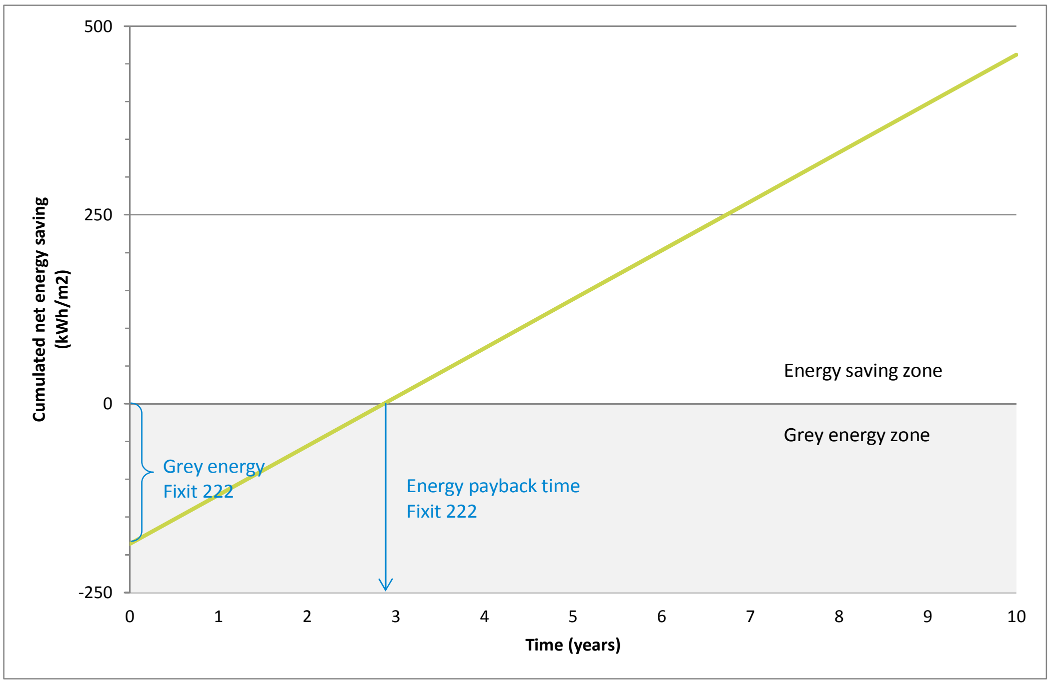

Figure 7: Grey energy und energy payback time for Fixit 222 Aerogel High Performance Insulating Plaster
The intersection of the line with the y-axis gives the absolute value of the grey energy. The intersection of the line with the x-axis gives the energy payback time.

Looking at the use of the plaster over the assumed serviceable life of 40 years, there is a cumulated net saving of primary energy due to insulation benefits of about 2,400 kWh/m², which corresponds to around 240 litres of heating oil per m² wall surface area (see Figure 8).

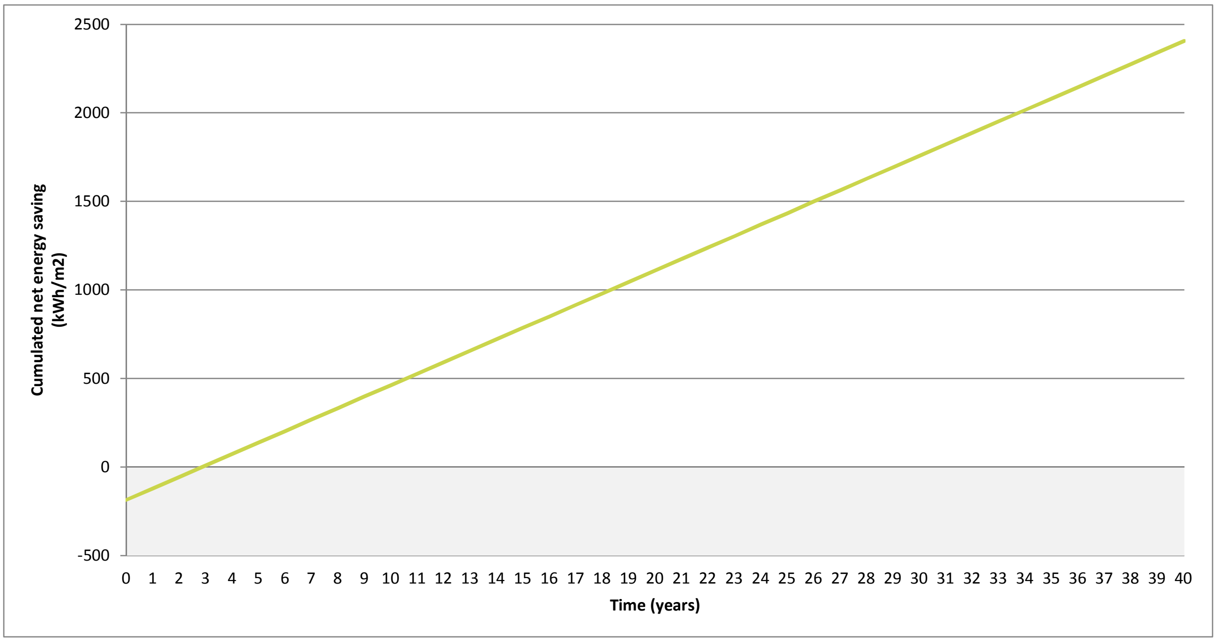

Figure 8: Net savings of primary energy through use of Fixit 222 Aerogel High Performance Insulating Plaster
The line shows the cumulated net saving of primary energy after application.

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