Environmental Product Declaration

in accordance with ISO 14025

Factory-made Polyurethane Insulation Products

IVPU
Industrieverband Polyurethan-Hartschaum e.V.

Declaration number
EPD-IVPU-2010112-D

Institut Bauen und Umwelt e.V.
www.bau-umwelt.com

Institut Bauen und Umwelt e.V.

Brief version

Umwelt-Produktdeklaration

Environmental Product Declaration

Programme holder

Institut Bauen und Umwelt e.V.

www.bau-umwelt.com

Declaration holder

IVPU e.V.
Im Kaisemer 5
D-70191 Stuttgart

Declaration number

EPD-IVPU-2010112-D

Declared construction products

Polyurethane Insulation Products

This Declaration is an Environmental Product Declaration in accordance with ISO 14025 and describes the specific environmental features of the construction products in Germany outlined here. It intends to promote the development of construction which is compatible with the environment and health.
This validated Declaration discloses all of the relevant environmental data.

This Declaration is based on the "PCR Foam Plastics" document of December 2009.

Validity

This validated Declaration entitles the holder to bear the symbol of the Institut Bauen und Umwelt e.V. It exclusively applies for the products referred to for a period of three years from the date of issue. The Declaration holder is liable for the details and documentation upon which the evaluation is based.

Content of the Declaration

The Declaration is complete and comprises in detail:

- Product definition and physical construction data
- Details on base materials and material origin
- Description of the product manufacturing process
- Information on product processing
- Data on the utilisation status, extraordinary effects and re-use phase
- Results of the Life Cycle Assessment
- Documentation and tests

Issue date

01 September 2010

Signatures

Prof. Dr.-Ing. Horst J. Bossenmayer
(President of Institut Bauen und Umwelt e.V.)

Testing the Declaration

This Declaration and the regulations upon which it is based have been tested by the independent Committee of Experts (SVA) in line with ISO 14025.

Signatures

Prof. Dr.-Ing. Hans-Wolf Reinhardt (Chairman of the SVA)

Dr. Frank Werner (tester appointed by the SVA)

Brief version

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Environmental Product Declaration

Product description

Polyurethane rigid foam (PUR/PIR) is a closed-cell factory-made thermal insulation product in the form of insulation boards with or without facings which is used for buildings, building equipment and industrial installations. The polyurethane insulation product family comprises the PUR and PIR product variants.

Polyurethane insulating products are manufactured in the form of bloc foam and as boards with flexible facings.

Area of application

Insulation products made of polyurethane foam are distinguished by outstanding thermal insulation properties and good compressive strength at low density. Typical areas of application include:

- thermal insulation in buildings (e.g. interior and exterior insulation for roofs, floors, ceilings and walls, incl. capillary-active)
- building equipment (e.g. insulating heating and hot water pipes)
- industrial installations (e.g. insulating pipelines, district heating lines, boilers, tanks and apparatus).

Scope of the LCA

The **Life Cycle Assessment (LCA)** was performed in accordance with DIN ISO 14040 ff. standard in line with the requirements of the guidelines to Type III declarations by the Institut Bauen und Umwelt e.V. Specific plant data as well as the “GaBi 4” were applied as a data basis. The life cycle assessment comprises the recovery of raw materials and energy, raw material transport and the actual manufacturing phase for polyurethane insulation boards. The declared unit is 1 m³ of PUR/PIR Alu (insulation boards with aluminium facings), PUR/PIR Mineral Fleece (insulation boards with mineral fleece facings) and PUR/PIR Bloc foam (slabstock without facings) at an apparent density of 30 kg/m³. The results are also indicated for exemplary board thicknesses based on m².

The basic data was collected within the framework of an internal Association survey. The Environmental Product Declaration therefore only applies for the products manufactured by members of the IVPU.

The manufacture and energy recovery of packaging are indicated in the results. The usage phase is not taken into consideration in the Declaration. Thermal treatment of the products with energy recovery was examined as a disposal scenario.

Results of the LCA

Polyurethane insulation panels (manufacture)									
	Polyurethane block WLS 030 (manufacture + end of life)			Polyurethane WLS 028 mineral fleece (manufacture + end of life)			Polyurethane WLS 024 alu (manufacture + end of life)		
Evaluation factor in units per m³	TOTAL	Manufacture (incl. transport)	EOL	TOTAL	Manufacture (incl. transport)	EOL	TOTAL	Manufacture (incl. transport)	EOL
Non-regenerative primary energy [MJ]	2269	2768	-499	2263.2	2773.2	-510	2424.53	2928.53	-504
Regenerative primary energy [MJ]	43.27	48.89	-5.62	42.14	47.84	-5.7	86.89	92.55	-5.66
Greenhouse w arming potential (GWP 100) [kg CO2 equiv.]	191.54	134.03	57.51	194.64	135.12	59.52	205.63	147.07	58.56
Ozone depletion potential (ODP) [kg R11 equiv.]	1.02E-06	2.19E-06	-1.17E-06	7.70E-07	1.96E-06	-1.19E-06	1.98E-06	3.16E-06	-1.18E-06
Acidification potential (AP) [kg SO_2 equiv.]	0.4284	0.425	0.0034	0.465	0.429	0.036	0.546	0.511	0.035
Eutrophication potential (EP) [kg PO_4 equiv.]	0.054	0.044	9.70E-03	0.054	0.044	1.01E-02	0.056	0.046	9.90E-03
Summer smog potential (POCP) [kg C_2H_4 equiv.]	0.071	0.071	1.99E-04	0.074	0.074	2.66E-04	0.079	0.079	2.34E-04

Brief version

Umwelt-Produktdeklaration

Environmental Product Declaration

Results of the LCA

Results for insulation panels of exemplary strengths per m²						
Evaluation factor in units per m²	**WLS 024 Alu**			**WLS 028 Mineral fleece**		
	TOTAL	**Manufacture (incl. transport)**	**EOL**	**TOTAL**	**Manufacture (incl. transport)**	**EOL**
Floor insulation U-value 0.26 W/(m²·K)	**8 cm**			**10 cm**		
Non-regenerative primary energy [MJ]	193.96	234.28	-40.32	226.32	277.32	-51
Regenerative primary energy [MJ]	6.9572	7.41	-0.45	4.22	4.79	-0.57
Greenhouse warming potential (GWP 100) [kg CO2 equiv.]	16.4548	11.77	4.68	19.462	13.51	5.95
Ozone depletion potential (ODP) [kg R11 equiv.]	1.59E-07	2.53E-07	-9.44E-08	7.70E-08	1.96E-07	-1.19E-07
Acidification potential (AP) [kg SO_2 equiv.]	0.043	0.040	0.003	0.044	0.04	0.004
Eutrophication potential (EP) [kg PO_4 equiv.]	4.50E-03	3.71E-03	7.92E-04	5.42E-03	4.41E-03	1.01E-03
Summer smog potential (POCP) [kg C_2H_4 equiv.]	6.37E-03	6.35E-03	1.87E-05	7.46E-03	7.43E-03	2.66E-05
Pitched roof insulation U-value 0.19 W/(m²·K)	**12 cm**			**14 cm**		
Non-regenerative primary energy [MJ]	290.94	351.42	-60.48	316.85	388.25	-71.4
Regenerative primary energy [MJ]	10.4308	11.11	-0.68	5.902	6.7	-0.80
Greenhouse warming potential (GWP 100) [kg CO2 equiv.]	24.6772	17.65	7.03	27.2528	18.92	8.33
Ozone depletion potential (ODP) [kg R11 equiv.]	2.37E-07	3.79E-07	-1.42E-07	1.08E-07	2.75E-07	-1.67E-07
Acidification potential (AP) [kg SO_2 equiv.]	0.064	0.060	0.004	0.065	0.060	0.00504
Eutrophication potential (EP) [kg PO_4 equiv.]	6.76E-03	5.57E-03	1.19E-03	7.58E-03	6.17E-03	1.41E-03
Summer smog potential (POCP) [kg C_2H_4 equiv.]	9.56E-03	9.53E-03	2.81E-05	1.04E-02	1.04E-02	3.72E-05
Passive house U-value 0.13 W/(m²·K)	**18 cm**			**20 cm**		
Non-regenerative primary energy [MJ]	436.41	527.13	-90.72	452.64	554.64	-102
Regenerative primary energy [MJ]	15.6512	16.67	-1.02	8.43	9.57	-1.14
Greenhouse warming potential (GWP 100) [kg CO2 equiv.]	37.0208	26.48	10.54	38.934	27.03	11.90
Ozone depletion potential (ODP) [kg R11 equiv.]	3.57E-07	5.69E-07	-2.12E-07	1.55E-07	3.93E-07	-2.38E-07
Acidification potential (AP) [kg SO_2 equiv.]	0.096	0.090	0.006	0.097	0.09	0.007
Eutrophication potential (EP) [kg PO_4 equiv.]	1.01E-02	8.36E-03	1.78E-03	1.08E-02	8.81E-03	2.02E-03
Summer smog potential (POCP) [kg C_2H_4 equiv.]	1.43E-02	1.43E-02	4.21E-05	1.50E-02	1.49E-02	5.32E-05

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Documentation and tests

In addition, the following **documentation and tests** are depicted in the Environmental Declaration:

- VOC
- Isocyanate emissions

Product group	Foam plastics	Created on
Declaration holder:	IVPU e.V.	01.09.2010
Declaration number:	EPD-IVPU-2010112-D	

Area of applicability

The Environmental Product Declaration applies for the products declared by the IVPU members Karl Bachl GmbH & Co KG, Paul Bauder GmbH & Co KG, Ecotherm Deutschland GmbH & Co KG, Linzmeier Bauelemente GmbH, puren gmbh, Recticel Dämmsysteme GmbH, Remmers Baustofftechnik GmbH and Steinbacher Dämmstoff-Gesellschaft mbH. The IVPU represents more than 90% of the polyurethane insulation market in Germany.

1 Product definition

Product definition

The Declaration refers to the manufacture of one cubic metre of PUR/PIR Bloc foam (slabstock without facings), one cubic metre of PUR/PIR Mineral Fleece (insulation boards with mineral fleece facings, calculated at a thickness of 14 cm) and one cubic metre of PUR/PIR Alu (insulation boards with aluminium facings, calculated at a thickness of 12 cm). Polyurethane rigid foam (PUR/PIR) is a closed-cell thermal insulation product in the form of insulation boards with or without facings used for buildings, building equipment and industrial installations. The polyurethane insulation product family comprises PUR and PIR.

Application

Insulation products made of polyurethane foam are distinguished by outstanding thermal insulation properties and good compressive strength at low density. Typical areas of application include:

- thermal insulation in buildings (e.g. interior and exterior insulation for roofs, floors, ceilings and walls, incl. capillary-active)
- building equipment (e.g. insulating heating and hot water pipes)
- industrial installations (e.g. insulating pipelines, district heating lines, boilers, tanks and apparatus)

Product standard / Approval

Factory-made thermal insulation materials made of polyurethane rigid foam for buildings are standardised to DIN EN 13165. The application is regulated in the DIN 4108-10 standard.

Quality assurance

The declared products bear the quality symbol of the Überwachungsgemeinschaft Polyurethan-Hartschaum (ÜGPU), which is a notified certification body. This symbol is based on quality surveillance and certification by independent accredited bodies.

Geometric data

Polyurethane insulation panels are manufactured with plane parallel surfaces or as tapered insulation boards displaying typical thicknesses of 20 to 300 mm. The board formats depend on the designated application. Widths can be up to 1250 mm with approximate lengths of up to 5000 mm. Pre-cut parts (e.g. pipe sections) are used for insulating building equipment and industrial installations.

Physical data

The apparent density of insulation boards for buildings complies with approx. 30 kg/m³. Depending on the area of application and requisite features, higher densities of up to 250 kg/m³ are possible.

Polyurethane insulation panels are manufactured in thermal conductivity levels

WLS 024 to 030. These levels correspond with the design values of thermal conductivity of 0.024 to 0.030 W/(m·K).

Modified capillary-active insulation boards display design values of up to 0.033 W/(m·K).

The declared compressive stress or declared compressive strength at 10% deformation comprises 100 or 150 kPa as per EN 826. Higher compressive strengths are possible.

Declared tensile strength as per DIN EN 1607 comprises 40 kPa. Higher tensile strengths are possible.

The water vapour diffusion resistance factor μ as per EN 12088 for polyurethane foam is between 40 and 200 in accordance with DIN 4108-4.

The maximum moisture absorption of polyurethane foam at diffusion and condensation to DIN EN 12088 is approx. 6 vol.-%. The water absorption measured over 28 days in a submersion test as per DIN EN 12087 is 1.3 vol.-% for a PUR/PIR insulation board (laminated with mineral fleece, apparent density of 35 kg/m³) of 60 mm thickness. In terms of the insulation product without facing, the moisture absorption in freeze/thaw cycles gives rise to values of between 2 and 7 vol.-%.

Polyurethane rigid foam displays distinctively thermosetting features and is therefore not meltable.

Fire protection

Polyurethane insulation products are classified as normally flammable (B2 as per DIN 4102-1 or E in accordance with DIN EN 13501-1) or low-flammable (B1 as per DIN 4102-1 or C in accordance with DIN EN 13501-1). Capillary-active insulation boards for internal lining covered with mineral top layers are classified as low-flammable when installed (B1 as per DIN 4102-1 or C in accordance with DIN EN 13501-1).

Pitched roof constructions with polyurethane insulation are classified as REI 30 (fire-retardant) in the P-MPA-E-04-025 general technical approval.

Roof assemblies with upper insulation made of polyurethane as per DIN 18234-2 also comply with the fire protection requirements of the industrial construction guideline for fire sections or fire-fighting sections with a roof area of more than 2,500 m².

2 Base materials

Base materials / Primary products

Insulation products made of polyurethane rigid foam arise following a chemical reaction between MDI (approx. 55-65 %) and polyol (approx. 20-30%) and the addition of low-boiling blowing agents (approx. 4-5%). Insulation boards with flexible facings are blown exclusively with the hydrocarbon pentane. Some low-flammable bloc foams contain partially-fluorinated hydrocarbons without ozone depletion potential (ODP). The blowing agent stays permanently in the foam cells thanks to its closed-cell properties.

Consumables / Additives

Water (approx. 0.1-0.5%), foam stabilisers (approx. 0.5-2%) and fire retardants containing phosphorous (approx. 2-5%) are added as additives.

Material definitions

The raw materials for the production of polyurethane are obtained across several intermediate stages primarily from crude oil. Polyols can be manufactured from sustainable raw materials (industrial sugar, glycerine, sorbite or vegetable oils).

Harvesting raw materials and origin of materials

MDI and polyols are largely manufactured from fossil refinery products in major technical plants. Synthesis occurs across several stages in closed loop manufacturing plants. Most of the production locations are in Germany and the Benelux states. The average transport distance for raw materials and facings used is 500 km. Transport is by truck.

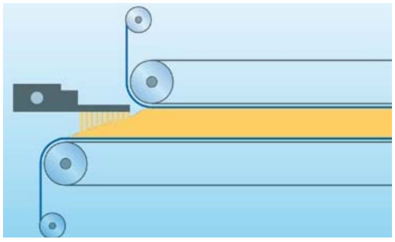
Regional and general availability of raw materials

Limited crude oil reserves are currently largely used for generating energy. Only approx. 4% of crude oil imports by the Federal Republic of Germany are used for the manufacture of plastics. As around 30% of primary energy requirements are attributed to buildings, reducing energy requirements by means of highly-efficient thermal insulation is of particular significance. The energy content of polyurethane insulation products can be extensively recovered via thermal utilisation.

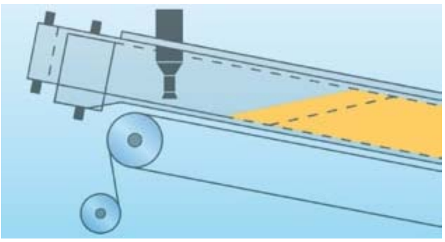
3 Product manufacture

Product manufacture

Polyurethane rigid foam insulation boards with flexible facings are manufactured by all IVPU members in a continuous process on a double belt conveyor. This manufacturing process involves the reaction mixture flowing from a mixing head to a lower facing made of flexible material where it foams up and adheres to a top facing applied from above within the pressure zone of the laminator. Mineral fleece or aluminium foils are primarily used as facings. The foam boards are cut to the requisite sizes after passing through the double belt conveyor.



For continuous production of bloc foam, the reaction mixture is applied to a U-shaped folded paper sheet supported along the sides which is then moved along by the transport belt. At the end of the transport belt, the foamed bloc can be cut to the requisite lengths. Polyurethane bloc foam is produced by Paul Bauder GmbH & Co KG and puren.



Health protection in manufacturing

During the entire manufacturing process, no other health protection measures are required extending beyond those legally specified industrial protection measures for commercial enterprises.

Environmental protection in manufacturing

Apart from the statutory specifications, no other special measures are required.

4 Product processing

Processing recommendations

Polyurethane insulation materials can be cut, sawn, milled or ground using standard tools and hand-held equipment to be used on a building site. Insulation boards are generally mechanically fixed (pitched and flat roof, core insulation). Alternatively, insulation boards can be installed loosely on the floor, for example. Gluing with hot or cold adhesive is also possible, taking consideration of the manufacturer's recommendations. Joints between cut insulation panels on roof ridges, edges or valleys must be sealed without a heat bridge using polyurethane construction foam.

Industrial safety / Environmental protection

Dust is incurred when processing with saws, grinding or milling tools. In the case of industrial applications, personnel should protect themselves by wearing a suitable dust filter mask (respiratory protection sheet published by the Chemical Industry's professional liability association). The dust concentration in the air (general dust limit value as per the Technical Rules Governing Hazardous Substances, TRGS nos. 900 and 901) should not exceed the following values:

10 mg/m³ (measured as an inhalable fraction)
3 mg/m³ (measured as an inspirable fraction).

Residual materials

Residual materials can be directed to domestic waste incineration plants for thermal utilisation provided that they can not be returned to the manufacturer for material re-use.

Packaging

Largely foils made of plastic are used as packaging material. They are disposed of via Interseroh AG in Cologne.

5 Condition of use

Contents

Under standard conditions of use, the construction material does not display any material change during the period of use.

For physical reasons, insulation materials must be installed airtight to the indoor air so as to prevent any direct contact with the interior.

Relationships between the environment and health

Polyurethane insulation boards are odour-neutral. The requirements of the General Committee for the Health Assessment of Construction Materials (AgBB) are complied with. Emission measurements in the test chamber analogue to the relevant test standards (DIN EN 717-1 and DIN (EN) ISO 16000-6, 9 and 11) indicated that minimum volumes of volatile organic compounds (VVOC, VOC) are released in the form of the hydrocarbon pentane. Polyurethane foam does not contain any volatile isocyanates.

Reliability of condition of use

Polyurethane rigid foam is non-rotting and resistant to most standard construction chemicals. Its useful life corresponds with the life cycle of the insulated construction components.

6 Extraordinary effects

Fire

Polyurethane foam is classified as “low-flammable” or “normally-flammable”.

In the event of a fire, PUR/PIR decomposes without causing droplets or burning particles. According to a test by the Materialprüfungsanstalt at the University of Stuttgart (MPA Stuttgart, Otto Graf Institute), polyurethane rigid foam is not susceptible to glowing combustion in the event of a fire.

Apart from soot-like decomposition products, fires give rise to water vapour, carbon monoxide and carbon dioxide as well as nitrogen oxides and traces of hydrogen cyanide as is the case when burning all organic substances containing nitrogen, e.g. wood or wool. The dangers associated with these combustion gases primarily depend on the volume of material burned in relation to the size of the room in which the gases are distributed and not least, the ventilation conditions prevailing during the fire.

Water

Insulation products made of polyurethane rigid foam do not absorb any moisture from the air owing to their closed-cell structure, i.e. they are not capillary-active. In the event of unforeseen exposure to water, e.g. flooding, only a very low volume of solvent substances is released.

7 Re-use phase

Re-use / Further use

As polyurethane insulation products are generally installed mechanically or loosely, recovery and mono-fraction compilation of waste is easily possible.

Clean and undamaged polyurethane insulation boards can be reused.

Clean polyurethane waste can be recycled in terms of finished materials or raw materials (glycolysis).

Polyurethane rigid foam waste is used in the manufacture of compressed rebonded board, whereby cuttings, installation and site waste are shredded before adding binding agents and pressing into board-shaped materials. PUR/PIR rigid rebonded boards are high-quality products which are used in insulating window frames and thermal bridge insulation, for example.

Glycolysis involves transforming polyurethane waste at approx. 200 °C into a liquid reclaim (glycolysis polyol) which can in turn be used as a raw material in the manufacture of polyurethane.

Disposal / Landfilling

Polyurethane insulation materials may not be landfilled in untreated state according to the Technical Guidelines Governing Municipal Waste. The energy content of the insulation material is recovered via thermal treatment.

Waste code number in accordance with the European Waste Index:

Construction site waste is 170604.

8 Life Cycle Assessment

Declared unit

The declared unit is 1 m³ (30 kg/m³) of PUR/PIR Alu (insulation boards with aluminium facings), PUR/PIR Mineral Fleece (insulation boards with mineral fleece facings) and PUR/PIR Block (block goods without facings) products. In order to illustrate the influence of thermal conductivity, pollution levels in relation to one square metre of product depending on its thickness are also indicated.

System limits

The selected system limits comprise the production of these products including extraction of the raw material to the packaged product at the factory gate as well as reuse of the product (end of life).

The (/GaBi 4/) data base was used for generating energy and transport. The review framework comprises the following details:

- production of all raw materials, preliminary products and consumables
- relevant raw material transport and packaging
- packaging including energy recovery thereof.

The usage phase is not taken into consideration in the Declaration.

Thermal treatment of the products with energy recovery was examined as a disposal scenario (section 7.4).

All products tested are produced in the plants of member companies of the IVPU. The data is based on surveys collated at three plants. Product-specific data surveys were performed. PUR/PIR block foam was then weighted via the respective production volume of two plants. The data for the insulation panels was arithmetically extrapolated in line with the technology for providing energy to the 9 plants, on the basis of the 3 participating plants.

Raw materials and recipes from all manufacturers in the IVPU are comparable. The raw material components are usually procured on the market by changing suppliers depending on what is available. As the raw material producers use the same plant technology for manufacturing the raw materials, e.g. MDI or polyol, there are hardly any differences here /IVPU/.

8.1 Manufacturing polyurethane insulation panels

Performance criteria All of the data from the operational data survey and all emission measurements available from production were taken into consideration in the model. Accordingly, material and energy flows with a share of less than 1% were also analysed. It can be assumed that the total of all neglected processes does not exceed 5% of the results in the effective categories. With the result that it would appear to be plausible that the performance criteria as per the IBU Guidelines have been complied with and/or the extent of data collated is actually higher.

Transport Transport of base materials for coating and polyurethane foam is included in the analysis with an estimated average distance of 500 km per truck with a maximum permitted load of 27 tonnes, Euro 3. Sales transport outside the system limits were not taken into consideration.

Period under review The data for the manufacture of the product tested relates to 2008. The Life Cycle Assessment was drawn up for the German IVPU member manufacturing plants. Consequently, the background processes also of relevance for Germany such as the provision of power or raw materials, for example, were used.

Background data The “GaBi 4” software system for modelling the products was applied for comprehensive analysis. All of the background data records of relevance for manufacturing and disposal were taken from the GaBi 4 software data base.

Data quality The data for the products tested was recorded directly in the factories. The majority of data for upstream chains originates from industrial sources and was collected under consistent time- and method-based constraints. The process data and background data used are consistent. Importance was attached to a high degree of completeness when collating material and energy flows of environmental relevance.

Allocation Allocations (i.e. distributing environmental loads for a process across several products) may have been performed in the background data records of the GaBi 4 data base used; if this is the case, they are filed in the associated individual documents.

Credits for electricity (Strom-Mix Deutschland) and heat (from Erdgas Deutschland) arising from thermal recycling of waste and packaging in a waste incineration plant have been taken into consideration.

In the analysis, it was assumed that the coating is not removed from the insulation material and the aluminium foil is therefore burned (estimate with “Burning commercial waste similar to domestic waste in MVA”), whereby credits are allocated for electricity and thermal energy.

Information on the usage phase Insulation products essentially determine the energy efficiency and therefore environmental effects of the building during the usage phase. The specific products are not however examined in the Life Cycle Assessment owing to the wide variety of usage options and should be included in system analyses at building level.

Useful life The useful life corresponds with the life cycle of the insulated construction components.

8.2 Reuse phase

General information

In addition to manufacturing, the disposal of products is also taken into consideration. As described in the section on “System limits”, it is integrated in the calculation and is outlined separately in section 8.4.

8.3 Depicting the analyses and evaluating manufacturing

Life cycle inventory analysis

The following chapter outlines the Life Cycle Inventory Analysis as regards primary energy requirements and waste, followed by the estimated impact.

Primary energy requirements

The following Table 8-1 indicates the primary energy requirements (regenerative and non-regenerative, both lower heating value H_u), broken down into the overall total of raw materials, production and packaging of 1 m³ of product.

Non-regenerative energy requirements for PUR/PIR Block foam are almost 2,768 MJ per m³, 2,773 MJ per m³ for PUR/PIR Mineral Fleece (facings calculated for a board thickness of 14 cm) and 2,929 MJ per m³ for PUR/PIR Alu (facings calculated for a board thickness of 12 cm). Low volumes of regenerative energies, including solar energy stored in biomass and wind and hydro power, are also required during manufacture. They result from the power consumption with its regenerative share in the national power mix.

Table 8-1: Primary energy requirements for the manufacture of 1 m³ of product

Analysis factor	Unit per m³	Total	Raw materials	Production	Packaging
PUR/PIR block					
Non-regenerative primary energy	[MJ]	2767.64	2698.08	51.98	17.58
Regenerative primary energy	[MJ]	48.89	45.16	2.62	1.11
PUR/PIR mineral fleece					
Non-regenerative primary energy	[MJ]	2773.20	2728.66	26.96	17.58
Regenerative primary energy	[MJ]	47.84	45.54	1.19	1.11
PUR/PIR alu					
Non-regenerative primary energy	[MJ]	2928.53	2884.83	26.11	17.58
Regenerative primary energy	[MJ]	92.55	90.29	1.15	1.11

Table 8-2: Primary energy requirements for the manufacture of 1 m³ of product in sample thicknesses

Analysis factor	Unit per m²	Total	
Floor insulation U-value 0.26 W/(m²·K)		**8 cm PUR/PIR 024**	**10 cm PUR/PIR 028**
Non-regenerative primary energy	[MJ]	234.28	277.32
Regenerative primary energy	[MJ]	7.41	4.79

Pitched roof insulation U-value 0.19 W/(m²·K)		12 cm PUR/PIR 024	14 cm PUR/PIR 028
Non-regenerative primary energy	[MJ]	351.42	388.25
Regenerative primary energy	[MJ]	11.11	6.70
Passive house U-value 0.13 W/(m²·K)		**18 cm PUR/PIR 024**	**20 cm PUR/PIR 028**
Non-regenerative primary energy	[MJ]	527.13	554.64
Regenerative primary energy	[MJ]	16.67	9.57

More detailed consideration of the make-up of non-regenerative primary energy requirements in Fig 8-2 taking PUR/PIR Block foam as an example indicates that crude oil and natural gas account for the most extensive share in their capacity as energy carriers. While pit coal, uranium and brown coal are of less significance. This distribution of energy carriers applies equally for each of the three products. The deviations in composition account for <1%.

Thermal utilisation in an average refuse incineration plant under German framework conditions in a dry process is assumed for packaging as well as production waste. This gives rise to electricity credits by substituting electricity in the public network in line with the German power mix and a steam credit in line with the average production of steam from natural gas.

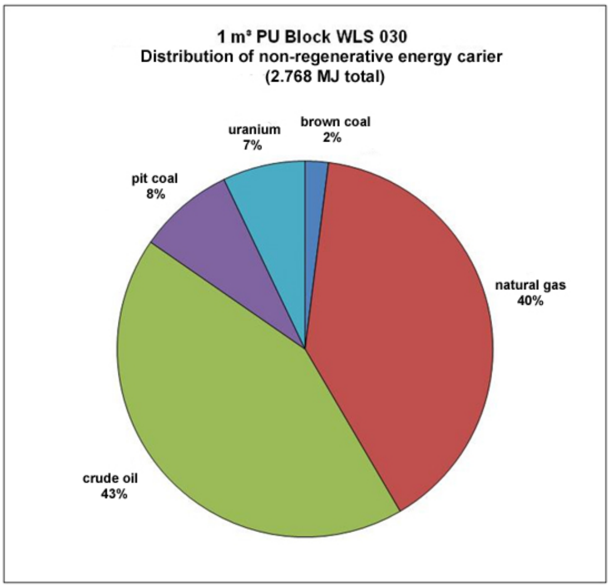


Fig. 8-2: **Distribution of requirements of non-regenerative primary energy by energy carrier by 1 m³ PUR/PIR Block**

Water requirements

The following volumes of water required for the manufacture of 1 m³ polyurethane insulation boards (Table 8-3). Water consumption by upstream processes (e.g. within the generation of electricity) is taken into consideration.

Table 8-3: Water requirements for the manufacture of 1 m³ of product

Polyurethane Insulation Panels			
Evaluation factor in units per m³	**PUR/PIR Block**	**PUR/PIR Mineral Fleece**	**PUR/PIR Alu**
Water (total) [kg]	6256	6251	6271

Waste

Waste volumes are depicted separately for the three areas: mining waste / pithead stocks (including ore treatment residue), commercial waste similar to domestic waste, special waste including radioactive waste (Table 8-4).

Mining waste represents the largest share of pithead stocks. Mining waste is incurred particularly in the preliminary chain of energy generation and in the preliminary chains of the raw materials used.

Special waste is essentially waste from upstream stages.

The following table indicates the waste volumes incurred by 1 m³ of product across the “cradle to gate” life cycle phases.

Table 8-4: Waste volumes across the life cycle of 1 m³ of product

Polyurethane Insulation Panels			
Evaluation factor in units per m³	**PUR/PIR Block**	**PUR/PIR Mineral Fleece**	**PUR/PIR Alu**
Mining waste / Pithead stocks [kg]	67.39	59.85	85.87
Commercial waste similar to domestic waste [kg]	0.65	0.74	0.72
Special waste [kg]	1.18	1.20	1.27
… of which radioactive waste [kg]	0.03	0.03	0.04

Estimated impact

Table 8-5 summarises the estimated impact of manufacture of 1 m³ of product.

Table 8-5: Estimated impact for the manufacture of 1 m³ of product

Polyurethane Insulation Panels			
Evaluation factor in units per m³	**PUR/PIR Block**	**PUR/PIR Mineral Fleece**	**PUR/PIR Alu**
Non-regenerative primary energy [MJ]	2768	2773.20	2928.53
Regenerative primary energy [MJ]	48.89	47.84	92.55
Greenhouse warming potential (GWP 100) [kg CO2 equiv.]	134.03	135.12	147.07
Ozone depletion potential (ODP) [kg R11 equiv.]	2.19E-06	1.96E-06	3.16E-06
Acidification potential (AP) [kg SO2 equiv.]	0.425	0.429	0.511
Eutrophication potential (EP) [kg PO4 equiv.]	0.044	0.044	0.046
Summer smog potential (POCP) [kg C2H4 equiv.]	0.071	0.074	0.079

The relative contributions by raw materials, production and packaging of 1 m³ product to the Greenhouse Warming Potential (GWP 100), Ozone Depletion Potential (ODP), Acidification Potential (AP), Eutrophication Potential (EP) and Photochemical Ozone Creation Potential (summer smog potential POCP) effect categories are depicted below.

In all effect categories, all products display a dominant influence by the raw materials and in this case also necessitated by MDI and polyester polyol. The coating materials allocated to the raw materials in the graphics display very different percentage shares depending on facing. The influence of mineral fleece facing reaches maximum 5% independent of the effect category taken into consideration. The aluminium facing displays a high share of 40% as regards ozone-depleting emissions while shares are between 6 and 18% in the other effect categories. Production is of relevance as regards ozone-depleting emissions and summer smog potential where it accounts for maximum percentages of 30%. The influence of packaging on the environment is less than 1%.

The Greenhouse Warming Potential (GWP) for each of the three products averages 98% from the raw materials directly. MDI and polyester polyol are primarily responsible for this. 82% of the emissions are carbon dioxide; approx. 4% is accounted for by nitrous oxide and around 14% are VOC emissions (especially methane).

The Ozone Depletion Potential (ODP) for each of the three products is attributable to the upstream processes (e.g. electricity generation) (Note: the blowing agents used have an ODP=0). The overall system gives rise to an Ozone Depletion Potential value of approx. 2.19E-06 / 1.96E-06 / 3.16E-06 kg R11 equiv. for PUR/PIR Bloc foam, PUR/PIR Mineral Fleece and PUR/PIR Alu.

The Acidification Potential (AP) and Eutrophication Potential (EP) for each of the three products can be almost fully attributed (99%) to the raw materials, whereby MDI and polyester polyol also play a decisive role here.

The Summer Smog Potential (POCP) for each of the three products is accounted for on average 72% by the raw materials and up to 31% by production. The summer smog potential is dominated by the VOC and sulphur dioxide.

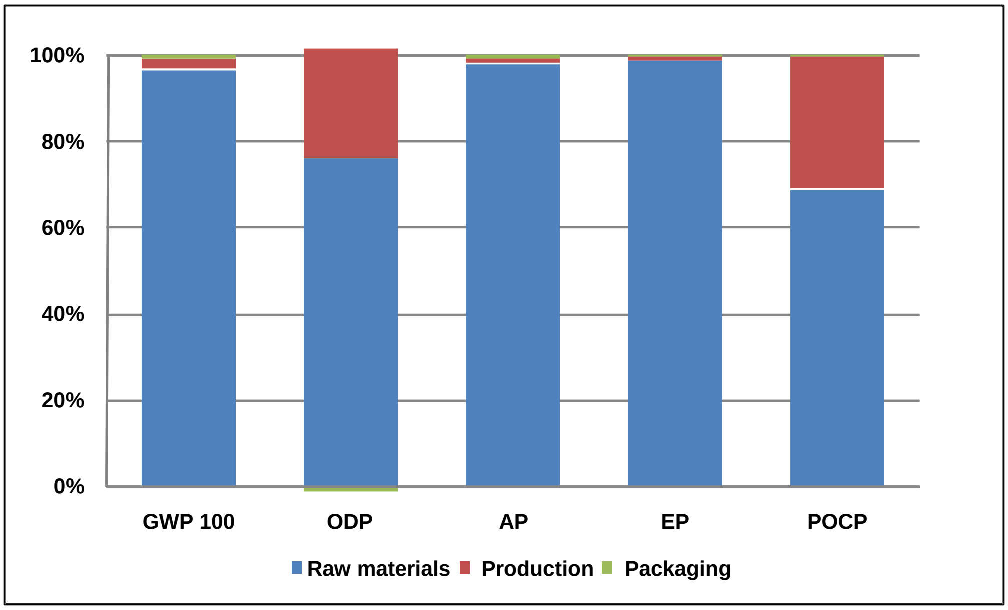


Fig. 8-3: **Relative contributions to environmental effects for the manufacture of 1 m³ PUR/PIR Bloc foam**

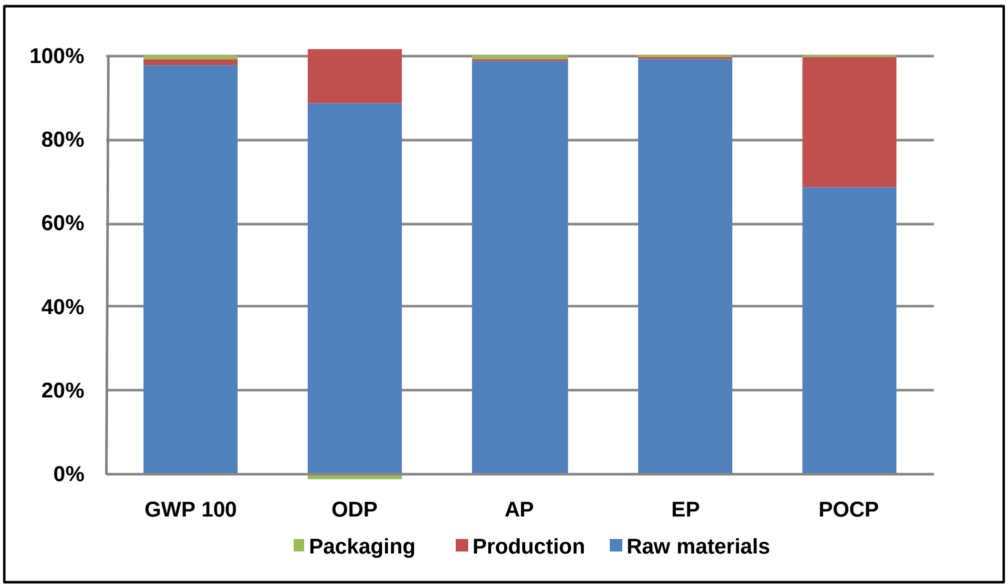


Fig. 8-3: **Relative contributions to environmental effects for the manufacture of 1 m³ PUR/PIR Mineral Fleece**

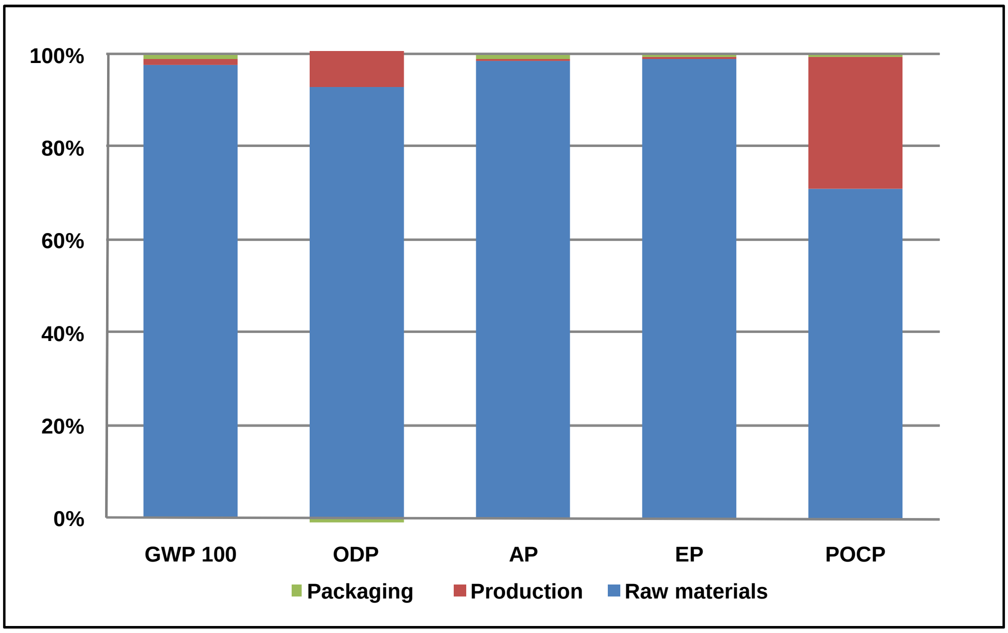


Fig. 8-3: **Relative contributions to environmental effects for the manufacture of 1 m³ PUR/PIR Alu**

8.4 Depicting the analyses and evaluating the reuse phase

Life cycle inventory analysis and estimated impact

Table 8-6 indicates the absolute contributions made by disposal to estimated impact and the influence on primary energy requirements.

Table 8-6: Absolute contributions (reuse phase) per cubic metre of product

Polyurethane insulation panels (reuse phase)			
Evaluation factor in units per m³	**PUR/PIR Bloc**	**PUR/PIR Mineral Fleece**	**PUR/PIR Alu**
Non-regenerative primary energy [MJ]	-499	-510	-504
Regenerative primary energy [MJ]	-5.62	-5.70	-5.66
Greenhouse warming potential (GWP 100) [kg CO2 equiv.]	57.51	59.52	58.56
Ozone depletion potential (ODP) [kg R11 equiv.]	-1.17E-06	-1.19E-06	-1.18E-06
Acidification potential (AP) [kg SO2 equiv.]	0.034	0.036	0.035
Eutrophication potential (EP) [kg PO4 equiv.]	9.70E-03	1.01E-02	9.90E-03
Summer smog potential (POCP) [kg C2H4 equiv.]	1.99E-04	2.66E-04	2.34E-04

These results describe the potential environmental effects of thermal utilisation and should be understood as a scenario. When availing of these LCA results at building level, more exact analysis of the real disposal channels and methods would be practical.

Thermal utilisation in the reuse phase can lead to a reduction in primary energy requirements and ozone-depleting emissions.

9 Requisite evidence

VOC

Measuring agency: Fraunhofer Institut für Holzforschung, Wilhelm Klauditz Institute WKI

Test report, date: Test report no. MAIC-2010-0370, dated 18 February 2010, Test report no. 2034/2004.

Result: The measurements were performed in test chambers in accordance with DIN EN ISO 16000-9. TENAX TA was used as an adsorbent; analysis was via GC/MS, analogue to DIN ISO 16000-6.
In the area of volatile organic compounds, only very low emissions were established. The emissions of pentane used as a blowing agent (VVOC) are under 150 µg/(m^3) after three days and under 60µg/(m^3) after 28 days.
The products display very low emission levels. No carcinogenic substances were detected.

Evaluation in accordance with the AgBB diagram (28 days):

Sample name: PUR insulation panel	
Overview of results 28 days	Measured values [µg/m³]
TVOC (C_6 – C_{16})	0
Σ VOC excl. NIK (C_6 – C_{16})	0
Σ SVOC (C_{16} – C_{22})	0.000
Σ cancerogens	0
Σ R_i [-]	0

The sample complies with the requirements of the AgBB diagram for the indoor use of construction products. .

Isocyanate exhalation

Measuring agency: Fraunhofer Institut für Holzforschung, Wilhelm Klauditz Institute WKI

Test report, date: Test report number 861/98 dated 7 December 1998 /IVPU/

Result: No release of isocynates was detected in the test in the 1 m³ test chamber. SUPELCO cartridges impregnated with 1-(2-Pyridyl)-piperazine were used for determining the MDI. Extraction was via the OSHA Method No. 47; analysis was via HPLC with fluorescence detection. The limit of detection is 10 ng/m³.

10 PCR document and examination

This Declaration is based on the "PCR Foam Plastics" document of December 2009.

Review of the PCR document by the Expert Committee. Chairman of the Expert Committee: Prof. Dr.-Ing. Hans-Wolf Reinhardt (University of Stuttgart, IWB)
Independent examination of the Declaration in accordance with ISO 14025: ☐ internal ☒ external
Validation of the Declaration: Dr. Frank Werner

11 Literature

/Eyerer 2000/ Eyerer, P. and Reinhardt, H.W. (pub.): Ökologische Bilanzierung von Baustoffen und Gebäuden – Wege zu einer ganzheitlichen Bilanzierung (Life Cycle Assessment of building materials and buildings) Birkhäuser Verlag Zürich, 2000

/GaBi 4/ GaBi 4: Software and data base for comprehensive analysis. LBP, University of Stuttgart and PE International, 2001-2008.

/ISO 14040/ DIN EN ISO 14040:2006-10: Environment Management – Life Cycle Assessment – Basic Principles and Framework (ISO 14040:2006); German and English versions EN ISO 14040:2006

/ISO 14044/ DIN EN ISO 14044:2006-10, Environment Management – Life Cycle Assessment – Requirements and guidlines (ISO 14044:2006); German and English versions EN ISO 14044:2006

/PCR 2009/ Institut Bauen und Umwelt e.V.: "PCR Foam Plastics" document, December 2009. www.bau-umwelt.com

/DIN EN 13501-1/ DIN EN 13501-1:2007-05, Classification of Building Products and Methods by Fire Performance – Part 1: Classification with the results of tests on fire performance by building products; German version EN 13501-1:2007

/WKI 2004/ Test reports on the emission of volatile components from polyurethane insulation materials, Nos. 659/2001 and 2034/2004, Fraunhoferinstitut für Holzforschung (WKI) in Braunschweig.

/EXCLI Journal 2009/ Hoffmann, Hans-Dieter; Schupp, Thomas: Evaluation of consumer risk resulting from exposure against MDI from polyurethane foam, article published in the EXCLI Journal 2009.

/Buchardt Boyd 2007/ Buchardt Boyd, Helle; Bügel Mogensen, Betty: Survey and health assessment of selected respiratory sensitizers in consumer products, published by the Danish Ministry of Environment, 2007.

/IVPU/ IVPU news: Expert article on the emission of volatile components from PUR foam thermal insulation materials, No. 64, June 1999

/ISO 14025/	DIN ISO 14025: 2007-10, Environmental Labels and Declarations – Type III Environmental Declarations – Basic Principles and Procedures (ISO 14025:2006); German and English versions DIN EN ISO 14025: Environmental labels and declarations - Type III environmental declarations - Principles and procedures, 2006
/DIN EN 13165/	DIN EN 13165 Thermal insulation materials for buildings - Fabricated products made of polyurethane foam (PUR) - Specifications; German version EN 13165:2008
/DIN 4108-04/	DIN V 4108-4:2007-08, Thermal Protection and Saving Energy in Buildings – Part 4: Technical Thermal and Moisture Protection Rated Values
/DIN 4108-10/	DIN 4108-10 Thermal Protection and Saving Energy in Buildings – Part 10: Application-related requirements on thermal insulation materials - Fabricated thermal insulation materials
/DIN EN 826/	DIN EN 826 Thermal insulation materials for the construction sector - Determining performance on pressure load; German version EN 826:1996
/DIN EN 1606/	DIN EN 1606:2007-06 Thermal insulation materials for the construction sector - Determining long-term creep performance on pressure load; German version EN 1606:1996 + A1:2006
/DIN EN 1607/	DIN EN 1607 Thermal insulation materials for the construction sector - Determining tensile strength vertical to panel level; German version EN 1607:1996
/DIN EN 12088/	DIN EN 12088 Thermal insulation materials for the construction sector - Determining water absorption via diffusion; German version EN 12088:1997
/DIN EN 12091/	DIN EN 12091:1997-08 Thermal insulation materials for the construction sector - Determining performance in freeze/thaw cycles; German version EN 12091:1997
/DIN EN 15801/	DIN EN 15801: 2008-04 Retaining the cultural legacy - Test methods - Determining water absorption via capillarity; German version prEN 15801:2008
/DIN V 4108-4/	DIN V 4108-4 Thermal Protection and Saving Energy in Buildings – Part 4: Technical Thermal and Moisture Protection Rated Values
/DIN 4102-1/	DIN 4102-1 Fire performance of building materials and components - Part 1: Building Materials, Terms, Requirements and Tests
/DIN 18234-2/	DIN 18234-2 Structural fire protection for large-surface roofs - Fire performance from below - Part 2: Directory of roofs complying with the requirements in accordance with DIN 18234-1; Closed roof areas
/DIN EN 29052/	DIN EN 29052-1:1992-08, Acoustics; Determining dynamic rigidity; Part 1: Materials used under floating screed in residential buildings; German version EN 29052-1:1991
/VDI 2243/	VDI 2243: 2002-07, Recycling-oriented Product Development

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Rheinufer 108

D-53639 Königswinter

Tel.: +49 (0)2223 296679-0

Fax: +49 (0)2223 296679-1

E-mail: info@bau-umwelt.com

Web: www.bau-umwelt.com

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This is to certify that the English translation of this document is a true translation of the German original submitted to me: Theley, Federal Republic of Germany, 27 July 2010

Marius J. Schütz:
Sworn Translator for the Courts and Notaries of the Saarland Judicial District, Saarbrücken, Federal Republic of Germany