Environmental product declaration (EPD) for PU (PUR/PIR) thermal insulation boards and energy saving potential

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1. Executive Summary

EPDs for construction products are a widely recognised and increasingly used tool to assess the environmental performance of buildings. The PU industry fully embraces the concept of EPD-based life cycle assessments of buildings and is committed to providing transparent and accurate data.

This factsheet summarises third-party verified data for different types of PU (PUR/PIR) thermal insulation boards from cradle-to-gate and, alternatively, from cradle-to-gate with energy recovery as end-of-life scenario.

The data now include the updated eco-profile for MDI, the most important PU precursor. This leads to a significantly improved environmental performance compared to the 2010 version.

LCA studies will show that the most important life cycle stage of insulation products is by far the use phase. Over its useful life, a PU insulation board can save over 135 times more energy than was used to make it.

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2. What is an Environmental Product Declaration?

An environmental product declaration (EPD) is a communication tool that provides quantified environmental information for a product, process or service on a harmonised and scientific basis covering the entire lifetime or parts of it. EPDs are not providing an evaluation of the environmental performance but are a comprehensive and transparent set of environmental information for a predefined set of life cycle stages. An important advantage of using EPDs is the possibility to add LCA-based information in the supply chain. This feature makes EPDs particularly valuable for the building sector where the final building is based on a large number of materials, construction products, semi-manufactured products and processes.

What is PU?

PU insulation stands for a group of insulation materials based on PUR (polyurethane) or PIR (polyisocyanurate). Their closed cell structure and high cross-linking density give them the characteristics of good heat stability, high compressive strength and excellent insulation properties. PU insulation has a very low thermal conductivity, starting from as low as 0.022 W/mK, making it one of the most effective insulants available today for a wide range of applications.

It must be made clear throughout the communication chain that EPDs cannot be compared with each other and only an assessment at the building (element) level, in a given end-use application, is relevant. Furthermore, LCA practitioners acknowledge as a rule of thumb that the error margins for primary energy use and global warming potential can be estimated at around 10 %, whereas a 20 % error margin usually applies to all other impact categories. This means that any differences within these margins should be considered as insignificant.

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3. PU Europe calculation tool

PU Europe **[1]** asked PE International to develop an updated, third-party verified EPD calculation programme based on EN15804. This tool is able to produce generic cradle-to-gate EPDs for different types of PU thermal insulation products including PU boards. It is linked to the Gabi software tool and database. Details on the background information and model can be obtained from the PU Europe office.

A sensitivity analysis demonstrated that modifications in the composition of the foam and the energy consumption of the foam production stage have no significant impact on the EPD results and therefore industry average data can be recommended for use in building assessments.

It is unfortunate that the mutual recognition of EPDs between countries is far from achieved in the EU. This adds costs to industry, affects the credibility of the system and provides a justification for third parties to develop alternative schemes.

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4. Updated EPDs for PU insulation boards

PU manufacturers and raw material suppliers are committed to continuously improving the environmental performance of PU insulation and providing accurate environmental data.

The first EPD revision included the up-to-date eco-profile for polyester polyols **[2]**. This second revision uses the new eco-profiles for MDI **[3]** and polyether polyols **[4]**. All precursor data are third-party verified.

Table 1: Environmental impacts of 1 kg naked foam following the 2013 update of the PU precursor life cycle inventory data sets (cradle-to-gate)

		EPD PU insulation board
Thermal conductivity	*W/mK*	0.028
Density	*kg/m³*	31
Thickness	*m*	0.032
Foam weight	*kg*	1
Insulation U-value	*W/m²K*	0.88
Insulation R-value	*m²K/W*	1.14
Primary renewable energy use	*MJ*	2.2
Primary non-renewable energy use	*MJ*	67.7
Total primary energy	*MJ*	69.9
Water use*	*m³*	0.0094
GWP	*kg CO_2*	2.9
ODP**	*kg CFC 11*	4.90E-06
AP	*kg SO_2*	0.0066
EP	*kg $(PO_4)^{3-}$*	0.0010
POCP	*kg Ethen*	0.0020
ADPE	*kg Sb*	4.74E-06
ADPF	*MJ*	63.7
Non hazardous waste*	*kg*	0.0362
Hazardous waste*	*kg*	0.0024
Radioactive waste*	*kg*	0.0015

** not declared in the certified EPDs (certain upstream data do not full comply with EN15804)*

*** can be rounded to zero*

GWP Global warming potential

ODP Ozone depletion potential

AP Acidification potential

EP Eutrophication potential

POCP Photochemical ozone creation potential

ADPE Abiotic depletion potential for non fossil resources

ADPF Abiotic depletion potential for fossil resources

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5. Average European cradle-to-gate EPDs for PU insulation boards

PU thermal insulation boards have the particularity to be supplied, in most of the cases, with various types of facings depending on the type of application and the required insulation performance **[5]**.

This factsheet provides several sets of EPDs: a set for the naked polyurethane foam for two basic reference units: 1 kg foam and 1 m² with a thermal resistance value of R=1. In addition, a set of four EPDs for insulation boards with a thermal resistance of R=5 and with different facings is provided.

With a view to further increasing the value of our EPDs, this updated factsheet distinguishes between a cradle-to-gate scenario and a scenario covering cradle-to-gate and end-of-life (energy recovery). The inclusion of energy recovery in the EPD leads to a significantly lower total primary energy use (51.4 MJ instead of 70.1 MJ per kg of naked foam), but increases the global warming potential from 2.9 kg CO_2 to 4.1 kg CO_2.

Table 2: Environmental impacts following two scenarios:

1. Cradle-to-gate: "Without"
2. Cradle-to-gate and end-of-life (energy recovery): "With"

Reference units: 1 kg/ 1 m² and thermal resistance R = 1 m²K/W

		Naked foam 1 kg		Naked foam R=1	
Thermal conductivity	*W/mK*	0.028		0.028	
Density	*kg/m³*	31		31	
Thickness	*m*	0.032		0.028	
Foam weight	*kg*	1		0.868	
Insulation U-value	*W/m²K*	0.88		1.00	
Insulation R-value	*m²K/W*	1.14		1.00	
End-of-life energy recovery		**without**	**with**	**without**	**with**
Primary renewable energy use	*MJ*	2.2	1.0	2.0	0.9
Primary non-renewable energy use	*MJ*	67.7	50.6	59.3	44.3
Total primary energy	*MJ*	69.9	51.6	61.3	45.2
Water use*	*m³*	0.0094	1.5281	0.0082	1.3336
GWP	*kg CO_2*	2.9	4.1	2.5	3.6
ODP**	*kg CFC 11*	4.90E-06	4.90E-06	4.29E-06	4.20E-06
AP	*kg SO_2*	0.0066	0.0051	0.0058	0.0045
EP	*kg $(PO_4)^{3-}$*	0.0010	0.0011	0.0009	0.0009
POCP	*kg Ethen*	0.0020	0.0018	0.0017	0.0016
ADPE	*kg Sb*	4.74E-06	4.70E-06	4.15E-06	4.10E-06
ADPF	*MJ*	63.7	49.2	55.7	43.0
Non hazardous waste*	*kg*	0.0362	0.0320	0.0317	0.0280
Hazardous waste*	*kg*	0.0024	0.0043	0.0021	0.0038
Radioactive waste*	*kg*	0.0015	0.0004	0.0013	0.0003

** not declared in the certified EPDs (certain upstream data do not full comply with EN15804)*

*** can be rounded to zero*

Table 3: Environmental impacts following two scenarios:

1. Cradle-to-gate: "Without"
2. Cradle-to-gate and end-of-life (energy recovery): "With"

Reference units: 1 m^2 of insulation board with a thermal resistance of R=5 m^2K/W

		Aluminium facing (100% virgin aluminium) R=5		Multilayer facing R=5		Mineral fleece facing R=5		Naked foam R=5	
Thermal conductivity	*W/mK*	0.023		0.023		0.026		0.026	
Density	*kg/m^3*	31		31		31		31	
Thickness	*m*	0.115		0.115		0.130		0.130	
Foam weight	*kg*	3.84		3.87		4.63		4.03	
Insulation U-value	*W/m^2K*	0.20		0.20		0.20		0.20	
Insulation R-value	*m^2K/W*	5		5		5		5	
End-of-life energy recovery		**without**	**with**	**without**	**with**	**without**	**with**	**without**	**with**
Primary renewable energy use	*MJ*	19.7	4.0	16.2	8.2	9.4	4.2	9.1	4.1
Primary non-renewable energy use	*MJ*	280.0	188.6	263.0	189.8	282.0	208.9	275.0	205.4
Total primary energy	*MJ*	299.7	192.6	279.2	198.0	291.4	213.1	284.1	209.5
Water use*	*m^3*	0.0653	-18.5882	0.0453	-1.1019	0.0394	7.8588	0.0382	6.2254
GWP	*kg CO_2*	13.4	14.9	11.5	15.1	12.4	17.6	11.8	16.4
ODP**	*kg CFC 11*	1.76E-05	1.76E-05	1.76E-05	1.76E-05	1.99E-05	1.99E-05	1.99E-05	1.99E-05
AP	*kg SO_2*	0.0393	0.0176	0.0295	0.0188	0.0287	0.0224	0.0268	0.0206
EP	*kg $(PO_4)^{3-}$*	0.0043	0.0038	0.0040	0.0041	0.0043	0.0046	0.0040	0.0043
POCP	*kg Ethen*	0.0082	0.0068	0.0077	0.0068	0.0090	0.0082	0.0080	0.0073
ADPE	*kg Sb*	1.83E-05	1.71E-05	1.79E-05	1.74E-05	3.06E-05	3.03E-05	1.93E-05	1.90E-05
ADPF	*MJ*	258.0	180.7	246.0	184.1	266.0	204.1	259.0	200.1
Non hazardous waste*	*kg*	0.5950	0.2439	0.2750	0.1600	0.1770	0.1604	0.1470	0.1299
Hazardous waste*	*kg*	0.0095	0.0168	0.0098	0.0203	0.0117	0.0416	0.0097	0.0174
Radioactive waste*	*kg*	0.0084	0.0088	0.0065	0.0069	0.0062	0.0016	0.0060	0.0016

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*** can be rounded to zero*

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6. The importance of the functional or reference units

It is important to take into account the density and thickness of any insulation material used in a particular end-use application. These two parameters will determine the overall weight and quantity of a specific insulant required for that application as well as its related environmental impacts. Comparative assertion at the building or component levels must also consider the knock-on effects of material choices on the thickness and structural strength of building elements and the possible need to add ancillary materials to achieve comparable building (element) performance. For insulation products, there are two useful types of functional or reference units:

- Those based on the thermal resistance, e.g. 1 m² of a wall element at a fixed R-value (or U-value). In this case, the use phase impacts related to energy consumption could be considered equivalent for the different solutions studied.

- Those based on the thickness of the insulant, e.g, 1 m² of a wall element with 5 cm of insulation. This reference unit is especially relevant in renovation projects, where the difference in thermal resistance may result in different thermal performance levels of the building element and therefore different use phase energy consumption and related environmental impacts.

*For additional support as to how to use EPD data please contact **PU Europe**.*

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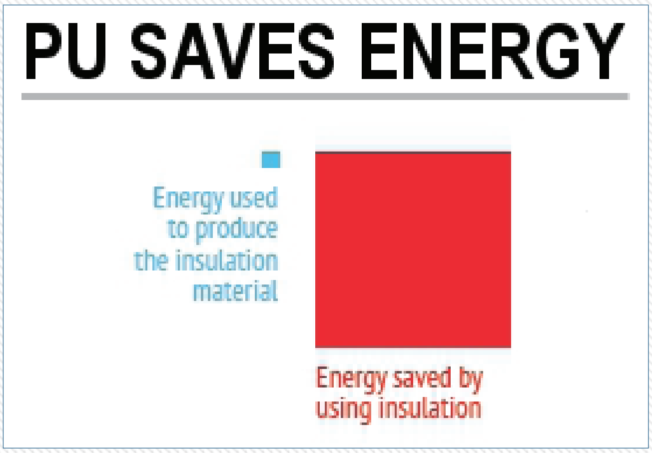
7. Use phase modelling: calculating energy savings



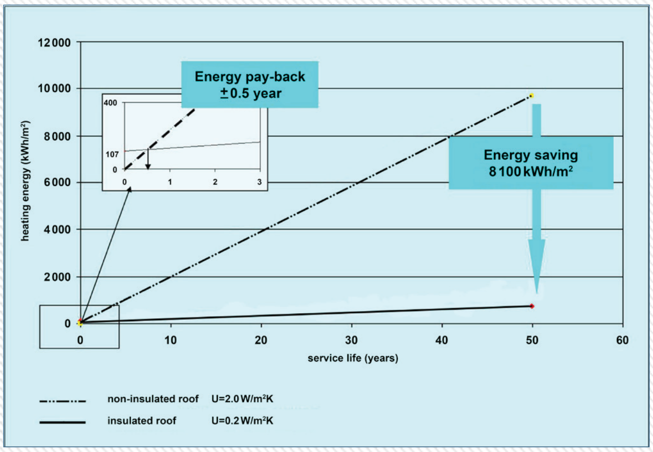
Next to the burdens from making PU insulation, it is important to determine its use phase benefits. This chapter offers an assessment of the potential savings that PU insulation can achieve over its life cycle using the modelling tool included in the third-party verified EPD calculation programme. The results compare a non-insulated building with a building insulated with PU (moderate climate). While these results cannot be extrapolated to all applications, they provide an interesting insight in the use phase benefits of PU high performance insulation.

The graph on page 7 shows that with only 115 mm of PU insulation, which is equivalent to an R-value of 5, annual energy savings of 162 kWh (582 MJ) of primary energy per m² insulated surface can be achieved. Over a 50 year lifetime, the savings will sum up to 8 100 kWh (29 100 MJ) per m², while only 82 kWh (or 293 MJ as calculated by the EPD) will be used to produce the 1 m² of board in the first place, almost a 1 to 100 ratio. If energy recovery as end-of-life scenario is included in the calculation, then the primary energy use for 1 m² of board would be reduced to 59 kWh (212 MJ). Under this scenario, the PU insulation would save 137 times the energy used for its production.

This also means that the amount of energy used to produce PU insulation is subsequently recovered in about half a year thanks to the energy saved in use phase.

Assuming a power price of 0.19€/kWh and a gas price of 0.13€/kWh, the PU insulation layer of 100 m² would save €105,000 over 50 years (non-discounted values assuming stable energy prices and no inflation).

Assumptions	
Degree days	3700
Insulation thickness	115 mm
Insulation R-value	5 m²K/W
Insulation U-value	0.2 W/m²K
Boiler efficiency	0.88
Space heating source	gas
Primary energy conversion efficiency	1.1
Primary heating energy demand	Q (kWh) = (U x surface x degree hours) * primary energy conversion / boiler efficiency



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8. Disclaimer

While all the information and recommendations in this publication are to the best of our knowledge, information and belief accurate at the date of publication, nothing herein is to be construed as a warranty, express or otherwise.

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9. References

[1] PU Europe is the European association of PU insulation manufacturers (**www.pu-europe.eu**)

[2] See **http://www.pu-europe.eu/fileadmin/documents/Reports_public/PU_10-204_PU_Europe_project_-_Eco-Profile_of_Aromatic_Polyester_Polyols__APP_.pdf**

[3] See **http://www.pu-europe.eu/fileadmin/documents/Other_reports_Other_research_projects/PU_12-092_ISOPA_Eco-profile_MDI-TDI_2012-04.pdf**

[4] See **http://www.pu-europe.eu/fileadmin/documents/Other_reports_Other_research_projects/PU_12-093_ISOPA_Eco-profile_Polyether_Polyols_2012-04.pdf**

[5] For more details see website **www.excellence-in-insulation.eu**