AFPR

Styropor® and the Environment

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Foam plastics

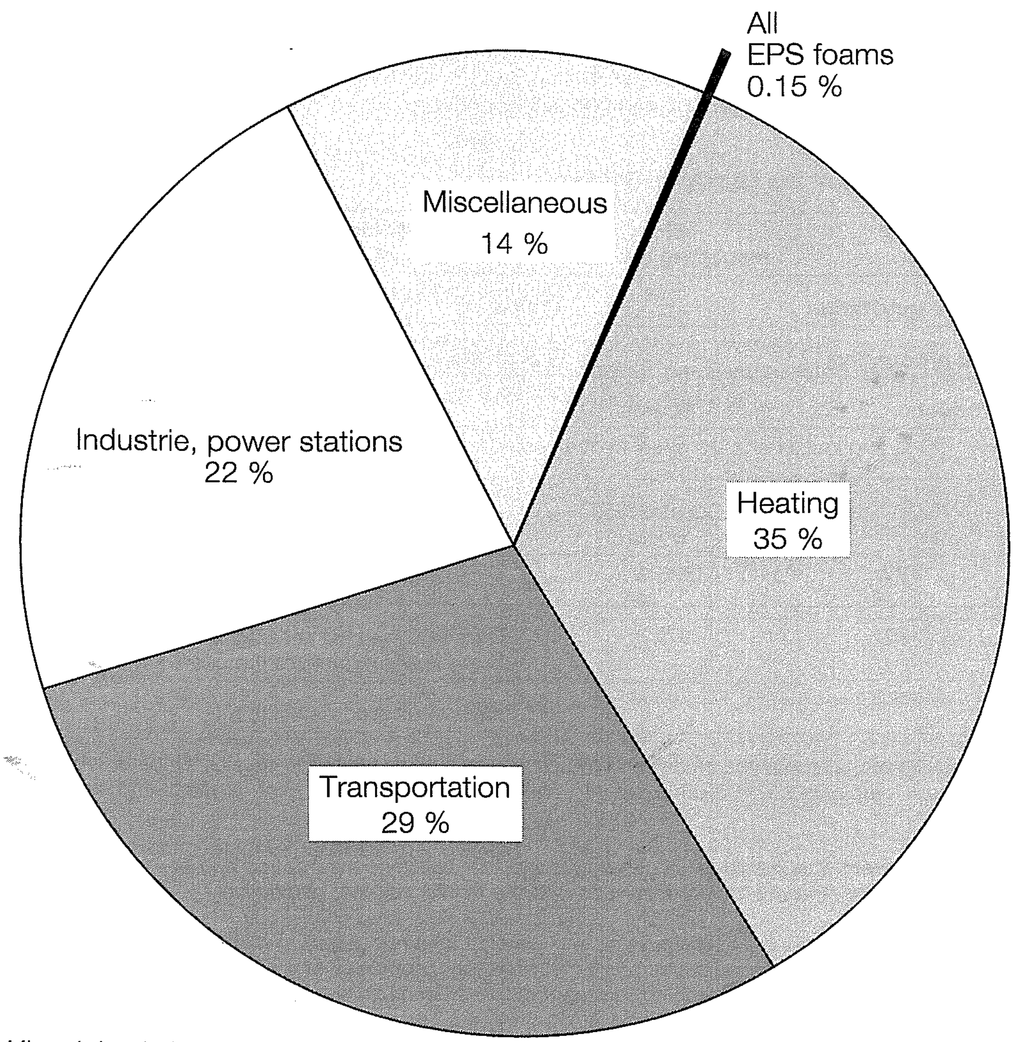
BASF

Resource consumption

The main areas of use for EPS foams in Germany are in the building sector with about 85 % and in the packaging sector with about 15 %. In the past, advantages in terms of product properties and/or price over rival products were enough to make them successful on the market. Today, environmental compatibility and recycling characteristics are also important decision-making criteria.

In the past, assessing the various product alternatives with regard to environmental properties was largely a matter of intuition. Mostly to the detriment of EPS products, since the amount of resources consumed by these products is widely overestimated by much of the population and many users (Figure 1). Therefore, the mere reference to "petroleum" as the raw material basic was usually enough for EPS products to be given an adverse assessment.

Because of these false perceptions, it was important for the foam manufacturing industry to produce comprehensive life cycle assessments in order to draw attention to the actual environmental impact of EPS, and to make it possible to make objective comparisons with rival products.



Source: Mineralwirtschaftsverband

Fig. 1: Petroleum Use (1995) in Germany

Life cycle assessments

In the meantime, such assessments are available for the two major applications of EPS:

- insulating materials for the building sector
- protective packaging

A comparative life cycle assessment of EPS/corrugated cardboard packaging has already been presented in several "Styropor and the Environment" publications [1]. The methodology developed by InFo Kunststoff e.V., Berlin, provided the basis for further life cycle assessments. The Industrieverband Hartschaum (IVH) [Industrial Association for Rigid Foam in Germany], Heidelberg, commissioned a life cycle assessment of EPS insulating materials, and the Informationszentrum Kunststoff (IZK) [Plastics Information Center], Bad Homburg, commissioned a comparative life cycle assessment of moulded pulp and EPS packaging. System limits, an inventory assessments, impact assessments and evaluations of the results will be presented in this article. The system limits of the two studies are presented in Table 1 a.

Table 1 a: System Limits of the Life Cycle Studies

	EPS-Insulating materials	Mouldings of EPS	Moulded pulp
Raw material acquisitation	Petroleum		Waste paper
Raw material production	EPS pellets		(Pulp/95 % water)
Finished product	Boards	Mouldings	
Recycling	Plant scrap		
	Construction waste	–	–
	–	used packaging	
Transportation	From raw material acquisition to delivery of the final products to the user		
	–	Return of used packagings	

In the inventory balance, all the steps involved in the process are investigated in detail and the energy consumption, solid waste, gaseous emissions and discharges into water are determined for each process and each transportation step.

In the impact assessment, the individual values determined for energy consumption and solid waste are added to form characteristic values, the energy consumption and the landfill volume, respectively.

In the case of gaseous emissions and discharges into water, it was necessary to standardize these values before compiling them because of the different environmentally relevant properties of the substances emitted. This standardization was carried out using the ambient concentration values specified in the study by the BUWAL [Swiss Federal Office for the Environment, Forestry and Agriculture] [2]. The critical air volume and the critical water volume from this study result from the use of the BUWAL data.

An additional parameter, the GWP value (Global Warming Potential), was also determined. This characteristic value indicates the greenhouse effect of the gases methane, carbon dioxide, dinitrogen oxide and pentane which are emitted during production, processing, recycling or recovery and rotting. On the basis of new findings published by the Umweltbundesamt [Federal Environment Office] [3], the GWP value for methane was raised to 35 in the life cycle assessment of moulded pulp/EPS packaging.

Since the results of the two assessments have different practical relevance, the results were evaluated separately.

Results of the life cycle assessment of insulating materials

In the building sector, additional insulating measures are required under the Wärmeschutzverordnung (WSVO 95) [ordinance on thermal insulation] for new buildings and in renovation work in Germany. Existing dwellings with inadequate insulation are not covered by this ordinance. The prime objective of the present life cycle assessment was to illustrate the environmental advantages possible through good insulation. It goes without saying that this data can also be used to compare EPS with other insulation materials [4].

Table 1 b: Results of the Life Cycle Assessment of Insulating Materials (standard data)

	Unit per m^3	**Foam density in kg/m^3 10**	**15**	**20**	**30**
Energy consumption	MJ	390	536	681	958
Critical air volume	$10^{-6}m^3$	5.7	7.6	9.6	13.5
Critical water volume	m^3	0.5	0.7	1.0	1.4
Landfill volume	dm^3	1.2	1.7	2.3	3.4
GWP	10^3	23.8	32.1	40.4	56.4
CO_2 emission	kg	20.0	26.8	33.5	48.0

Source: InFo Kunststoff e.V., Berlin: „Lebenswegbilanz von EPS-Dämmstoff"

With this data we can now calculate the actual environmental impact of EPS. We selected for this purpose a standard one family house moderately insulated (WSVO 84) and another one well insulated (WSVO 95) with Styropor for comparison with a poorly insulated house (DIN 4108). See Table 2a.

The improvements in connection with oil consumption can be seen in Table 2b and reductions of CO_2 emissions can be seen in Table 2c.

Table 2a: Example of a Detached One Family House

Thermal insulation conforming to		**DIN 4108**	**WSVO 84**	**WSVO 95**
Effective floor area	m^2	132.2	132.2	132.2
Area/Volume (A/V) ratio	m^{-1}	0.84	0.84	0.84
Existing K_m value	$\frac{W}{m^2 \cdot K}$	1.08	0.63	0.38

Source: IVH (Special reprint of "Lebenswegbilanz von EPS-Dämmstoff")
[Life cycle assessment of EPS insulating materials].

Table 2b: "Energy Expenditure/Energy Benefit"

Thermal insulation conforming to		**DIN 4108**	**WSVO 84**	**WSVO 95**
Heating energy demand per year[1)]	kWh/a	24630	12419	6015
Thermal insulation Styropor (PS15SE, PS20SE)	m^3	–	18,76	42,58
Oil equivalent of the thermal insulation	l	–	292	670
Heating energy saving per year	l	–	1221	1862
Heating energy savings over 50 years	l	–	61050	93100
Energy amortization[2)]	Month	–	1.9	2.8

[1)] *Based on heat transmission losses through the roof and walls of a building*

[2)] *Based on 236 heating days as specified by VDI 2067*

Tabelle 2c: "CO_2 Emissions"

Thermal insulation conforming to		**DIN 4108**	**WSVO 84**	**WSVO 95**
Caused by heating per year[1)]	kg/a	8098	4234	2178
Caused by production of Styropor (PS15SE, PS20SE)	kg	–	519	1189
CO_2 reduction over 50 years	kg	–	192681	294811

[1)] *Based on heat transmission losses through the roof and walls of a building*

Results of the comparative life cycle assessment of "Moulded pulp/ EPS packaging"

This assessment is primarily concerned with comparing the environmentally relevant effects of the use of these two products. A practical reference variable is very important here to make a fair comparison. Since neither specific mass figures nor specific volume figures provide anything like a true reflection of actual in use conditions, a new reference variable had to be developed. InFo Kunststoff e.V. has defined this new variable as the Mass Usage Ratio (MUR).

On the basis of practical comparisons of actual applications and literature searches, an MUR of 2.5 was set as the functional comparison value. This value means that, in comparable applications, pulp moldings are taken to be heavier than EPS moldings by a factor of 2.5.

InFo Kunststoff e.V. was not able to ascertain any reliable figures on the composition of the effluent from the production of pulp moldings. This also has an effect on the calculated value for the landfill volume. Therefore, these two characteristic values had to be deleted. Table 3 contains the characteristic values determined by the life cycle assessment [5].

To make possible comparisons with other Mass Usage Ratios as well, the results have been presented in break-even diagrams (Figure 2). These can also be used to determine the mass usage ratios which result in the same amount of environmental pollution as in the case of the two packaging variants. It must be noted here that Mass Usage Ratios of less than 2.5 usually do not provide adequate protective function.

Table 3: Life Cycle Assessment for Molded Pulp and EPS Packaging

	Unit*	**Mouldings of Moulded pulp** from	to	**EPS**
Energy consumption	MJ	1571	1990	925
	%	170	215	100
Critical air volume	$10^6 m^3$	14,0	16,9	12,9
	%	108	131	100
GWP	10^3	267	283	63
	%	424	449	100

* per m^3 of foam or comparable quantities (MUR = 2.5) of pulp mouldings

Source: InFo Kunststoff e.V., Berlin: „Lebenswegbilanz von Papier-Faserfußverpackungen und Vergleich mit EPS-Verpackungen

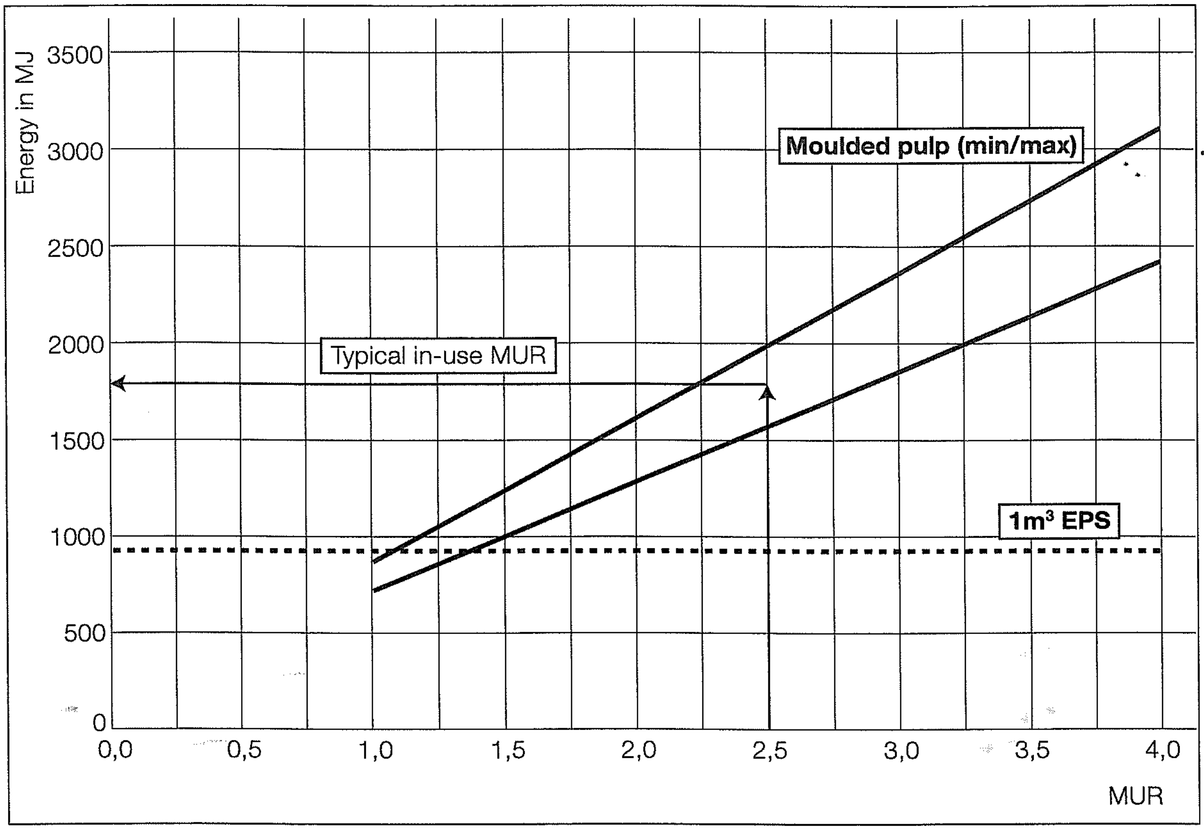


Fig. 2a: Comparison of the Energy Consumption of EPS and Pulp Mouldings

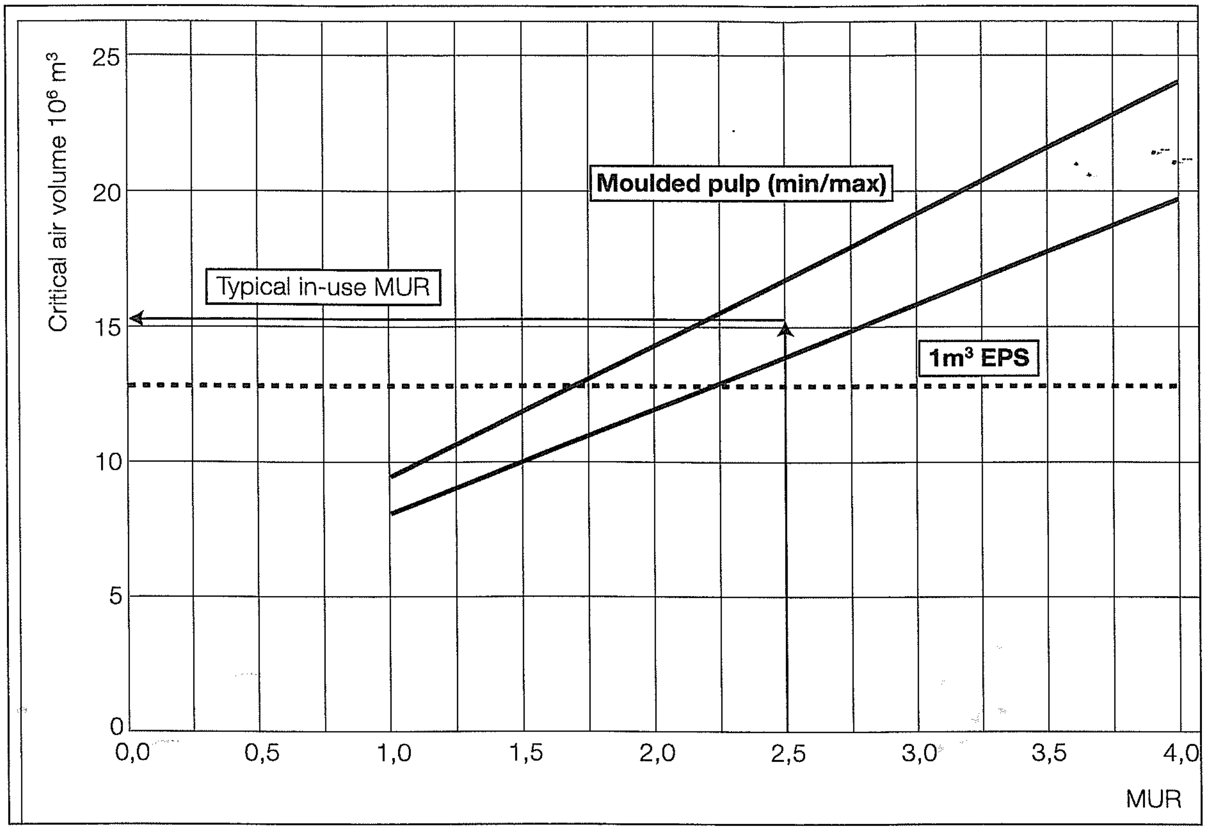


Fig. 2b: Comparison of the Total Air Emissions from EPS and Pulp Mouldings

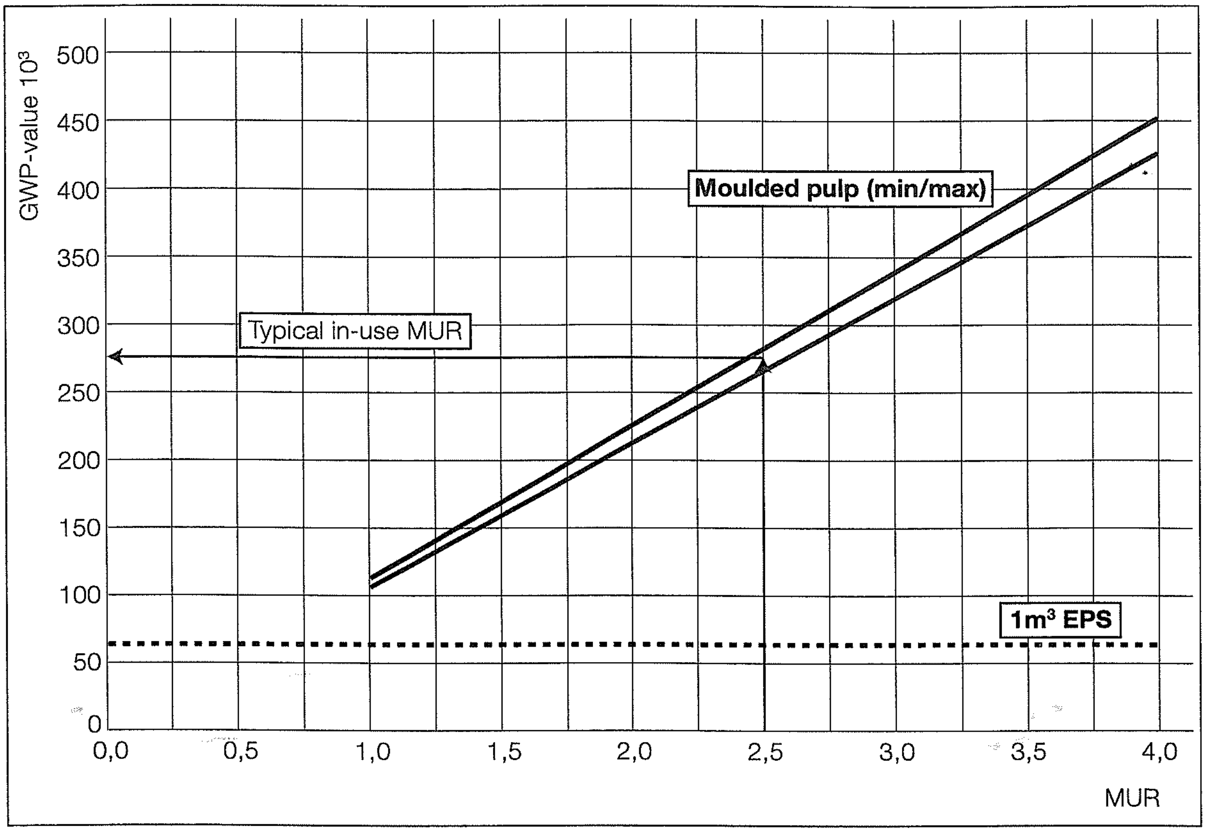


Fig. 2c: Comparison of the GWP Values of EPS and Pulp Mouldings

Life cycle assessments describe the environmentally relevant properties of the products at a particular point in time, i.e. for a particular state of technical development. Further developments of the product or changes brought about by increasing the recycling quota, will allow the overall environmental impact to be reduced. Current developments in this respect are presented below.

Improvement in the EPS life cycle assessment data for the use of products with reduced blowing agent levels

The life cycle assessments were made on EPS with a blowing agent content of 6%. Lower blowing agent contents allow improvements with regard to the critical air volume and the GWP value. Developments in recent years show that such products are being used for more and more applications. Important reasons for this development are also the advantages that low-pentane EPS products provide in processing and/or in the properties of the finished foam products. Table 4 shows comparisons of blowing agent emissions and the lower, customarily used apparent densities for products from standard grades and from special grades with reduced blowing agent contents. The advantages of EPS grades with reduced blowing agent contents are:

- uniform pre-expansion,
- shorter intermediate storage times,
- better internal fusion, particularly in the case of high densities,
- less post-shrinkage, and
- lower blowing agent emissions.

Table 4: Comparison between Styropor Standard Grades and Special Products with Reduced Blowing Agent Contents

Styropor Grades	Blowing agent content	Change in blowing agent emissions	Recommended minimum foam densities
Standard Products P*/F*			
P 123 VF 015 P 223 VF 215 P 323 VF 315 P 423 VF 415	ca. 6%	100%	**14 to 18 kg/m³, with continuous pre-expansion**
Special Products (P*/F*)			
P 240 F 295 P 340 F 395 P 440 F 495	< 4%	60–67%	**20 to 30 kg/m³ (P) 15 kg/m³ (F) with discontinuous pre-expansion**

P* = products **without** fire retardant
F* = products **with** fire retardant

Improvement in EPS life cycle assessment data through higher recycling quotas

The life cycle assessments for packaging are based on a recycling quota of 64%. Even back in 1994, EPS processors were able to achieve a recycling quota of 70% [7]. Because EPS packaging is also recycled by smaller-scale recycling companies, and because some EPS manufacturers who previously brought in raw materials have now installed their own recycling plants, it is becoming increasingly difficult to determine an exact figure for the recycling quota. However, the considerable activity in this area means that a further increase in the recycling quota is to be expected.

The following recycling applications which have long been known and proven successful (Figure 3):

- an alternative feedstock for foam production,
- use as a soil conditioner,
- an agent for making porous bricks,
- additives for improving heat insulation and reducing the weight of concrete, and

  insulating plasters and insulating mortars.

In addition, new applications have also been developed. For instance, for about 2 years now, ground EPS foam particles coated with a fire retardant have been used successfully as loose fill insulation in sloped roofs and in floor cavities [8].

A new process is also being used for producing EPS [6] from used EPS packaging. The production stages involved are:

- Grinding up molded foam parts,
- Extrusion to form pellets of recycled polystyrene (PS),
- Dissolving the recycled PS in styrene and polymering it to form EPS.

In this process, the amount of recycled material in the styrene is limited to about 20%. The advantages over products produced using mechanical blowing installations are: bead-form feedstock with customary bead size distributions and finished product properties of the same quality as from virgin material. By adding reground foam to the prepuff, EPS foam products can also be produced with a higher total recycle content.

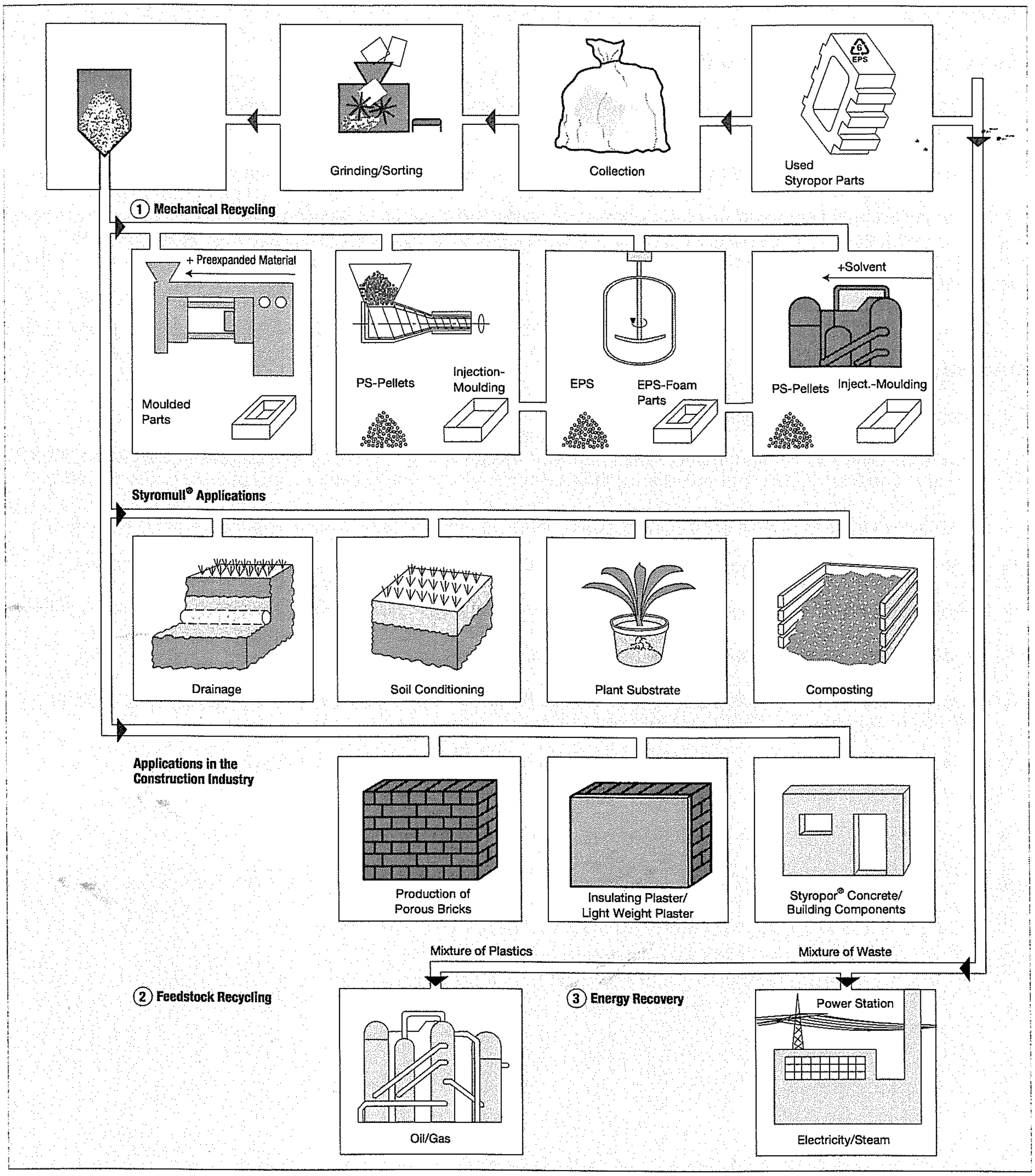


Fig. 3: Recycling Processes for Used EPS foam

Summary:

The life cycle assessments just presented show that

- EPS heat insulation materials contribute significantly to energy savings and the reduction of environmental pollution.
- EPS packaging offers considerable environmentally relevant advantages over alternative packaging materials.

Further improvements can be achieved by using raw materials with reduced blowing agent contents and by increasing the recycling quota. In addition to the possibilities described, virtually all optimization processes from raw material production to recycling or recovery lead to even more favourable life cycle assessments and environmentally friendlier products.

Literature references

[1] Styropor and the Environment

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[5] Interdisziplinäre Forschungsgemeinschaft InFo – Kunststoff e.V. [Interdisciplinary Research Association], Berlin.

[6] Technical data sheets HSR/MS – D 700, BASF AG, Ludwigshafen.

[7] Industrieverband Kunststoffverpackungen e.V. [Industrial Association for Plastics Packaging], Press release (960102) of January 29, 1996, Bad Homburg v.d.H.

[8] HEXAFLOCK® 2000, Company publication by Hexaflock 2000 GmbH, 77652 Offfenburg.

Further questions?

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