Life Cycle Assessment of ETICS End of Life Treatment of Expandable Polystyrene

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Life Cycle Assessment (LCA) of ETICS End-of Life treatment

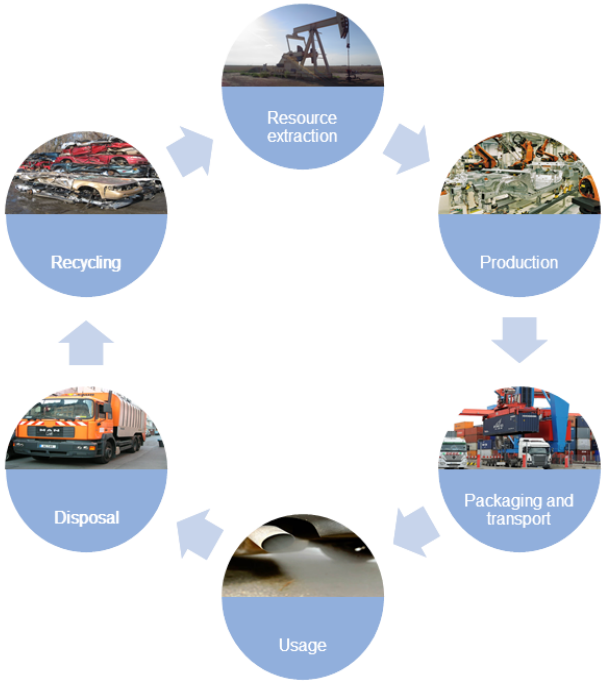
- LCA is a technique to assess the potential environmental impacts of products or processes throughout their entire life cycle – including production, use and end of life

- Consistency with ISO 14040:2006 and 14044:2006

- Scope of the study: provide a comparative LCA for the end of life treatment options
  - Energy recovery (status quo)
  - PSLoop

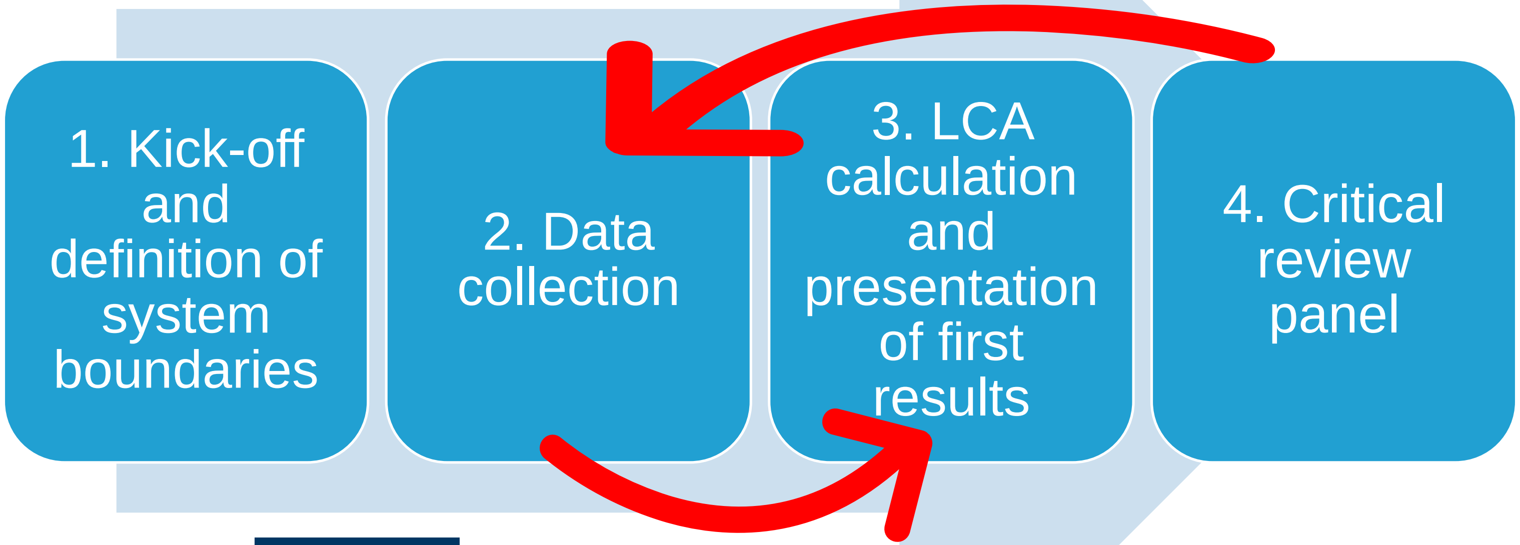
of 1 ton of EPS coming from External Thermal Insulation Composite System (ETICS) from dismantling of houses in Germany, Austria and Switzerland

→ Economic feasibility is so far not covered by this LCA!



Source. TÜV Rheinland, 2017

Timeline: LCA incl. critical review panel 2016 - 2017



Prof. Kind, Karlsruhe

1. Kick- off and definition of system boundaries

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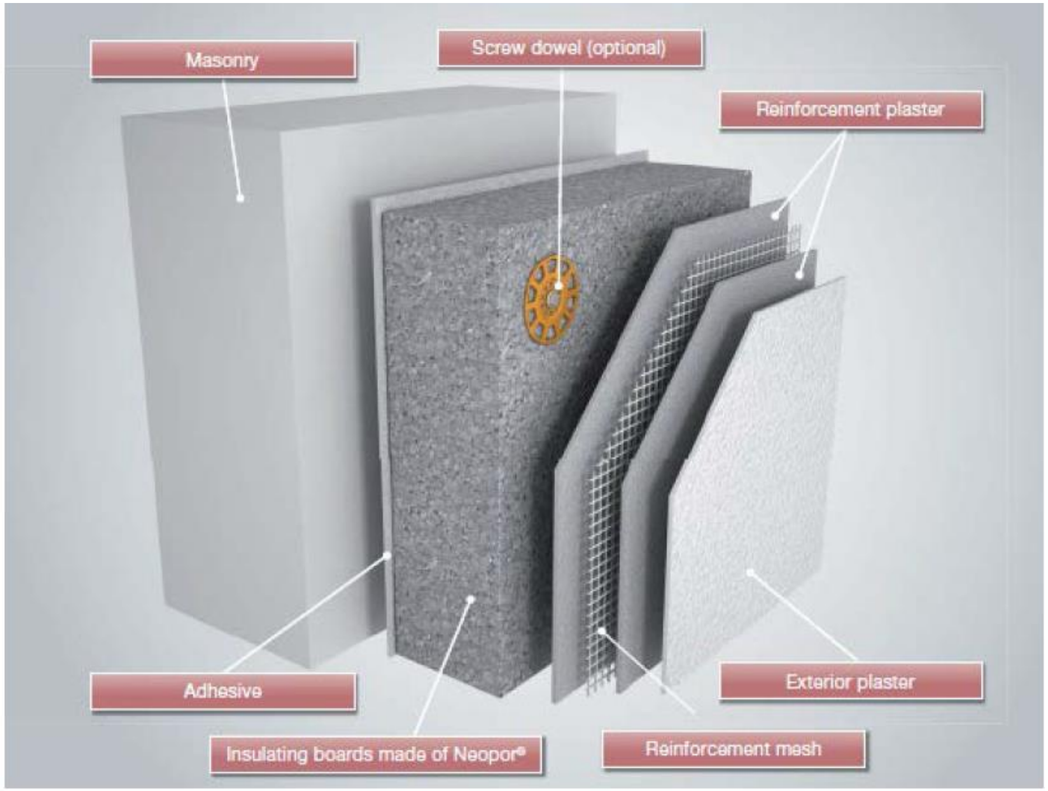
Masses of installed ETICS components to this day

31,6%	**10%**	32,2%	1,5%	24,2%	0,5%
adhesive	EPS	plaster	fabrics	finishing coat	dowels



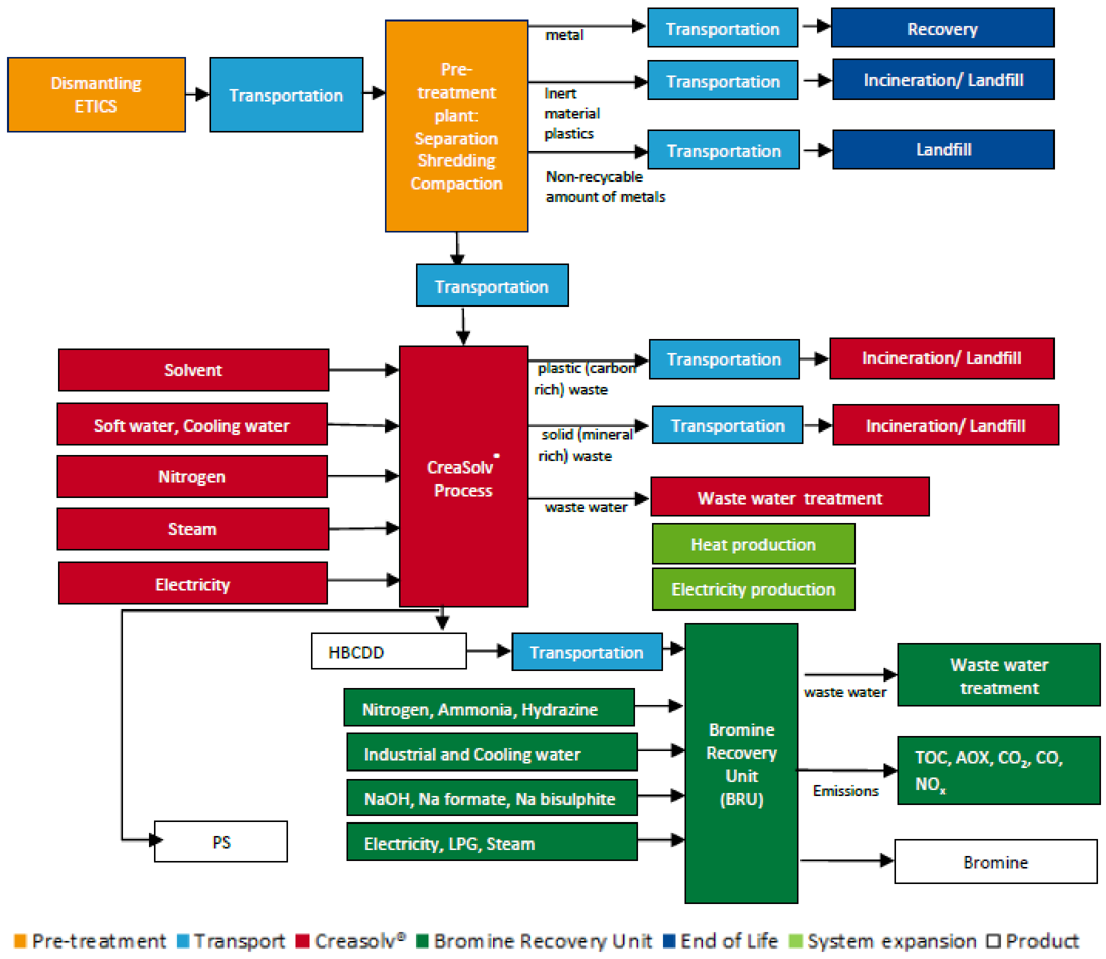
Source:
Albrecht, W. und Schwitalla, C. 2014: Fraunhofer Institut für Bauphysik IBP-Bericht BBHB 019/2014/281: Rückbau, Recycling und Verwertung von WDVS „Möglichkeiten der Wiederverwertung von Bestandteilen des WDVS nach dessen Rückbau durch Zuführung in den Produktionskreislauf der Dämmstoffe bzw. Downcycling in die Produktion minderwertiger Güter bis hin zur energetischen Verwertung“ ; ISBN-978-3-8167-9411-0, Fraunhofer IRB-Verlag

2. Data collection

Modelling & data base

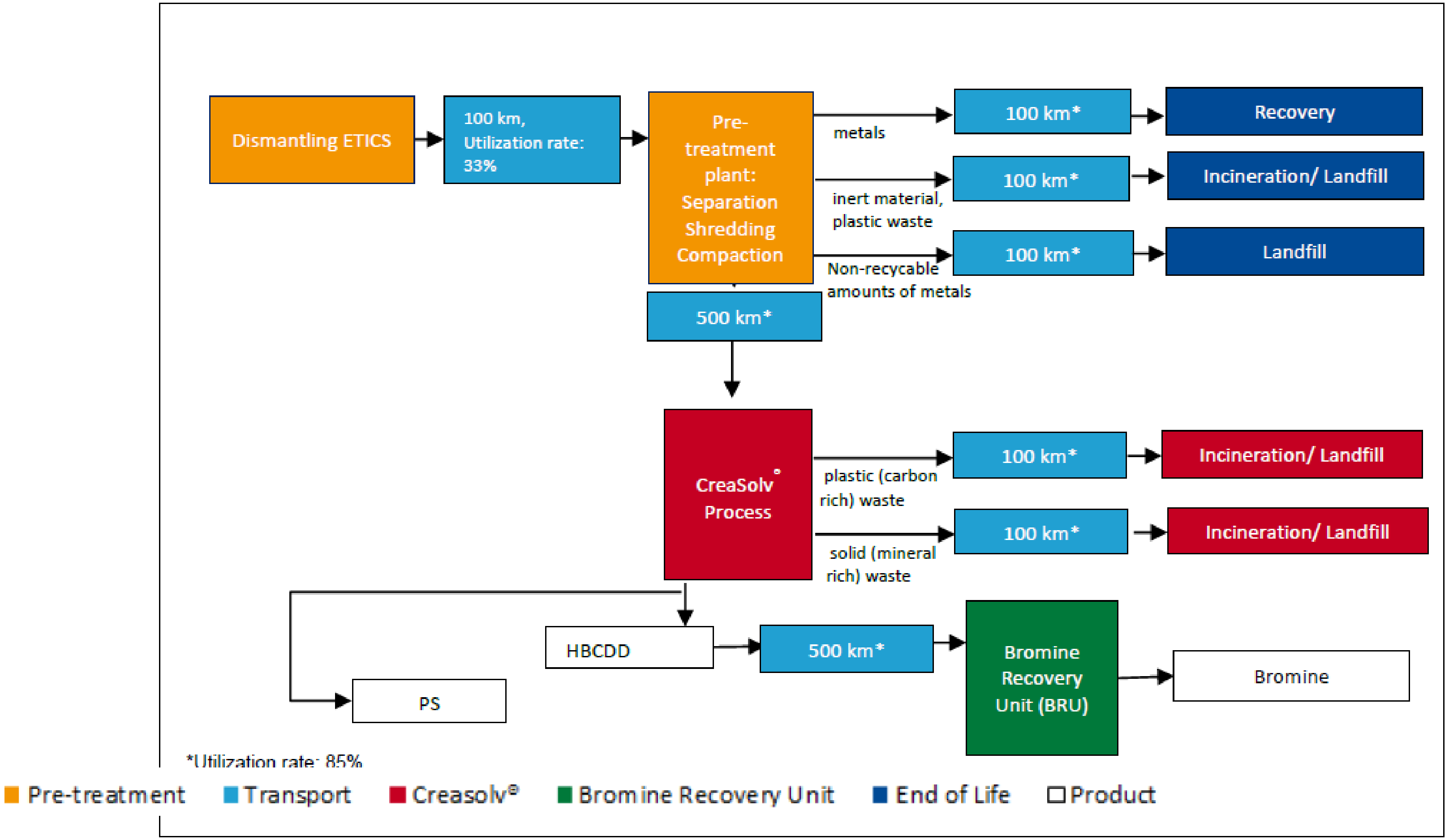
- Data for CreaSolv® Process originate from lab-scale trials and for the BRU from a pilot plant in the Netherlands provided by EPC and ICL-IP. The trials consider an input material of 30 kg compacted EPS briquettes with 1.5 wt% HBCDD. Data for the BRU originate from a pilot plant in Terneuzen (production run with an output of 400 kg bromine recovery per hour).
- IWARU Technical Center of FH Münster provided estimated data on the pre-treatment process (basis: 30,000 t ETICS per year) of ETICS producing shredded and compacted EPS-rich feed for further processing by the CreaSolv® Process. All data reflect the production in the year 2016.
- The inventories for all other processes are expert judgments or are based on literature sources. The modelling was carried out using the GaBi ts 7.2 software of thinkstep AG53.

Flow Chart: PS Loop Process



Source:
TÜV Rheinland (2017): Life Cycle Assessment for End of Life Treatment of Expandable Polystyrene (EPS) from External Thermal Insulation Composite Systems (ETICS), Figure 2, p.12

Transport distances (base case)



Source:
TÜV Rheinland (2017): Life Cycle Assessment for End of Life Treatment of Expandable Polystyrene (EPS) from External Thermal Insulation Composite Systems (ETICS), Figure 3, p.17

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Assumptions 1/3

Current Status Quo Process incineration with energy recovery- base case:

- For the demolition of houses an energy demand of 0.2 MJ/kg ETICS is assumed (assumption TÜV Rheinland based on Graubner & Hulin44).
- The transportation utilization rate for the transport step from demolition to incineration plant is 33%, caused by the relative low density of EPS.
- All incineration processes result in recovery of electricity and steam for the given regional scope. This assumption is mainly valid for Germany (due to the reason that many EPS originates from Germany (see chapter 1.1).
- A distance of 100 km (assumption TÜV Rheinland) from deconstruction to incineration plant is defined

Assumptions 2/3

PS Loop Process- base case:

- For the demolition of houses an energy demand of 0.2 MJ/kg ETICS is assumed (assumption TÜV Rheinland based on Graubner & Hulin45).

- Energy demand for separation, shredding and compaction of EPS is 0.13 MJ/kg EPS (information from IWARU Technical Center of FH Münster46).

- The transportation utilization rate for the transport step from demolition to pre-treatment plant is 33%, caused by the relative low density of EPS. All other materials are calculated with an utilization rate of 85% (assumption TÜV Rheinland). A distance of 100 km from dismantling to pre-treatment and to further treatment, as well as for production wastes of the CreaSolv® Process is considered.

- The initial CreaSolv® Plant will be built in Terneuzen, Netherlands. If the demo plant in Terneuzen runs successfull, the intention is to have several decentralized CreaSolv® plants located over Europe, starting with Germany. To reflect this development a distance of 500 km to CreaSolv® Plant (assumption one plant Germany) and 500 km to the BRU in Terneuzen (transport from Germany to the Netherlands) are assumed.

Assumptions 3/3

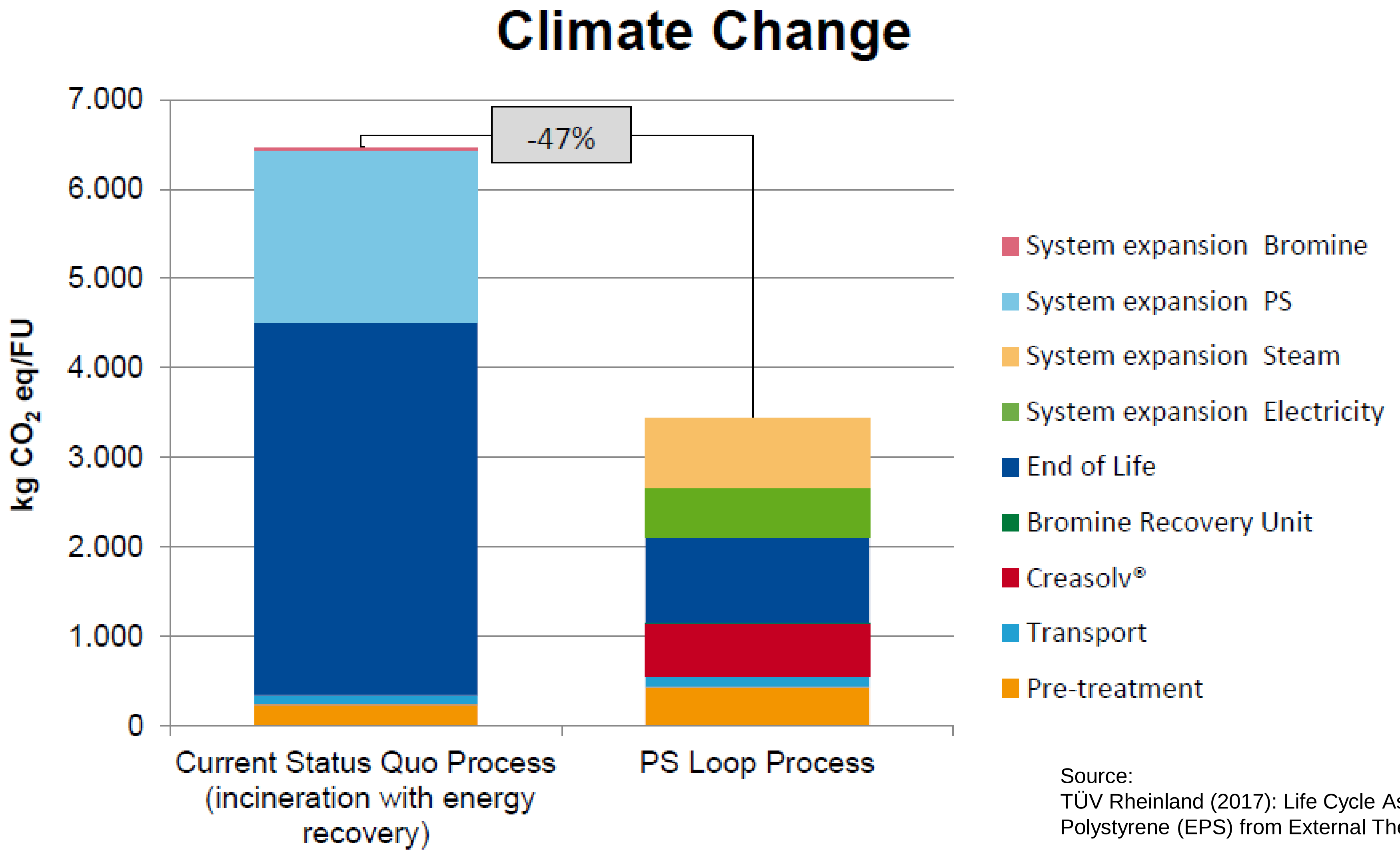
- Assumptions concerning end of life treatment:

Alternative	Material	Treatment	Source
Current Status Quo Process (incineration with energy recovery	Material mix A	89.5 wt% incineration of inert matter (plaster, adhesive, finishing coat, fabrics) 10.1 wt% incineration of plastic (10.0 wt% EPS and 0.1 wt% PE dowels (plastic parts)) and 0.4 wt% dowels (metallic parts): 90% wt recycling/ 10 wt% landfill	IWARU Technical Center of FH Münster
PS Loop Process	Material mix B	89.5 wt% incineration of inert matter (plaster, adhesive, finishing coat, fabrics) 0.1 wt% incineration of PE dowels (plastic parts)), 0.4 wt% dowels (metallic parts): 90% wt recycling/ 10 wt% landfill	IWARU Technical Center of FH Münster
	EPS (10 wt%)	Recycling (CreaSolv® Process)	-

Source:
TÜV Rheinland (2017): Life Cycle Assessment for End of Life Treatment of Expandable Polystyrene (EPS) from External Thermal Insulation Composite Systems (ETICS), Table 2, p.19

3. LCA calculation and presentation of first results

Climate Change



Source:
TÜV Rheinland (2017): Life Cycle Assessment for End of Life Treatment of Expandable Polystyrene (EPS) from External Thermal Insulation Composite Systems (ETICS), figure 8, p.34

Results of other environmental parameters

- In following impact categories PolyStyrene Loop has a **lower overall environmental impact** compared to the current status quo (energy recovery)
  - Climate change (-47%)
  - Eutrophication, freshwater (-26%)
  - Summer smog (-15%)
  - Resource depletion – fossil (-51%)
  - Resource depletion – elements (-17%)
  - Human-toxicity – cancer (-85%)
  - Human-toxicity – non cancer (-57%)
  - Ecotoxicity freshwater (-80%)
- For the impact categories “Acidification” and “Eutrophication, marine” PolyStyreneLoop perform similar to energy recovery
- System expansion (especially production of polystyrene) influences the results. The pre-treatment has only a small impact on the overall results
- The overall impacts of transportation steps are not relevant for both alternatives. A slightly higher impact for PS Loop occurs caused by a lower utilization rate
- Higher share of EPS (e.g. flat roof applications) leads to no significant changes in this impact category “Climate Change”

4. Sensitivity analysis

- In order to investigate the robustness of the study results, and to avoid false interpretation of the results based on assumptions, sensitivity analyses were carried out by investigating the effect of the following parameter choices on impact results.

Scenario	Base Case Assumption	Scenario Assumption
1- Dismantling method	Demolition	Selective Deconstruction
2- Treatment of material mix A& B	Incineration	Landfill
3- Allocation approach	System expansion	50:50 allocation approach
4,5- Fractions of EPS in ETICS	10 wt%	12 wt%, 15 wt%, 100 wt%
6,7*-Settings for CreaSolv® Process	Table 6	Table 22, Table 24
8*- Settings for BRU process	Recovery rate 95 %	Recovery rate 90%
9- Electricity Grid Mixes	European grid mix	German and Dutch grid mix
10- Transport Distance	100 km	2,000 km
11- Treatment of Material Mix A& B	incineration	50% incineration/ 50% landfill

* Scenarios 6 to 8 were carried out to show different recovery rates of PS and use of various amounts of solvent (CreaSolv® Process) as well as different recovery rate of bromine (BRU process).

Source:
TÜV Rheinland (2017): Life Cycle Assessment for End of Life Treatment of Expandable Polystyrene (EPS) from External Thermal Insulation Composite Systems (ETICS), table 10, p.76

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Results of the sensitivity analysis

- Scenario 1: No significant differences occur between the Current Status Quo Process (incineration with energy recovery) and PS Loop Process for climate change if another deconstruction method is used (3% difference).
- Scenario 2: a different treatment method for the inert material leads to no significant changes (difference: 9%) in this impact category.
- Scenario 3: a different allocation method leads to significant changes in this impact category.
- Scenario 4, 5: No significant differences result for other considered impact categories by assuming different masses of EPS for installed ETICS components. For some considered impact categories significant changes (> 15% differences) result, due to changes of life cycle steps pre-treatment and end of life.
- Scenario 6: No significant differences result for other considered impact categories by assuming different settings for the CreaSolv® Process.
- Scenario 7, 8: Some other considered impact categories resulting in significant changes (> 15% differences), due to changes of in- and outputs of the CreaSolv® Process. Consideration of different settings for the BRU Process leads to nearly no changes (difference: 0.01%) in relation to base case calculations.
- Scenario 9: No significant difference (difference between 4 % and 7%) between the Current Status Quo Process (incineration with energy recovery) and the PS Loop Process occur for climate change if another grid mix is considered.
- Scenario 10: the assumed transport distances lead to significant changes in this impact category.
- Scenario 11: Results show no significant changes (difference: <15%) in this impact category.

5. Critical Review

Task of the Critical review panel

- Review of the LCA with regard to ISO 14040 and 14044 conformance
- Compilation of comments from the reviewers (face-to-face meeting)
- Revision/ adaption of the LCA calculations accordingly
- Preparation of final review report and review statements

Feedback from the reviewers

Overall, the critical review team found the quality of the chosen methodology and its application in the analysis to be adequate for the purpose of the study and in conformance with the ISO 14040 and ISO 14044 standards. The reporting of the study and its results are transparent. The discussion of the results covers the relevant aspects in accordance with the goal of the study, and the conclusions are well founded on the outcome of the study and in line with the defined goal.

For the PS Loop Process the study describes a future recycling scheme with large-scale application in place, which is currently still in the development phase. This results in some uncertainties with respect of waste streams and specifications as well as process data, in particular for the CreaSolv® Process. As stated in the study, the Technology Readyness Level (TRL) varies between TRL 3 (experimental proof of concept) and TRL 4, which mean technology and used data is validated in lab scale.
In order to subsequently remove some of these inherent uncertainties it is recommended to perform a comprehensive update of the study on the basis of results and experiences gathered from operating the pilot plant.

Dr. Michael Spielmann | Prof. Dr.-Ing. Matthias Kind | Ulrich Schlotter

Source:
TÜV Rheinland (2017): Life Cycle Assessment for End of Life Treatment of Expandable Polystyrene (EPS) from External Thermal Insulation Composite Systems (ETICS), p.111

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