End of Life (EoL) Mattress Recycling

AGENDA

- The issue / Macro-economic background
- Material mix / Annual volumes / Characteristics
- Legislation
- Eol-process & options
- Economics
- Conclusions

1. The issue

- Up to 30 million mattresses annually reach their EoL in the EU. Estimated volume: 450 Ktons.

- EoL mattresses are currently (estimated)
  - 60 % landfilled
  - 40 % incinerated (mainly waste to energy)

- Several companies in France, The Netherlands, U.K. and Germany operate so-called mattress recycling units which in reality are limited for 90 % + to collection and dismantling.
  The PU and latex EoL trim is sold on the trim foam market competing and partly substituting virgin production trim.

2. Macro-economic background

- Municipal solid waste generation per capita amounts to approx. 525 kg/year and is expected to grow over the coming decades as a consequence of the global quality of life improvement.

- World population is expected to grow from 7 to 9 billion by 2050 and hence the demand for resources such as oil, gas, coal, ores, etc... will exceed the planet's currently known capacity.

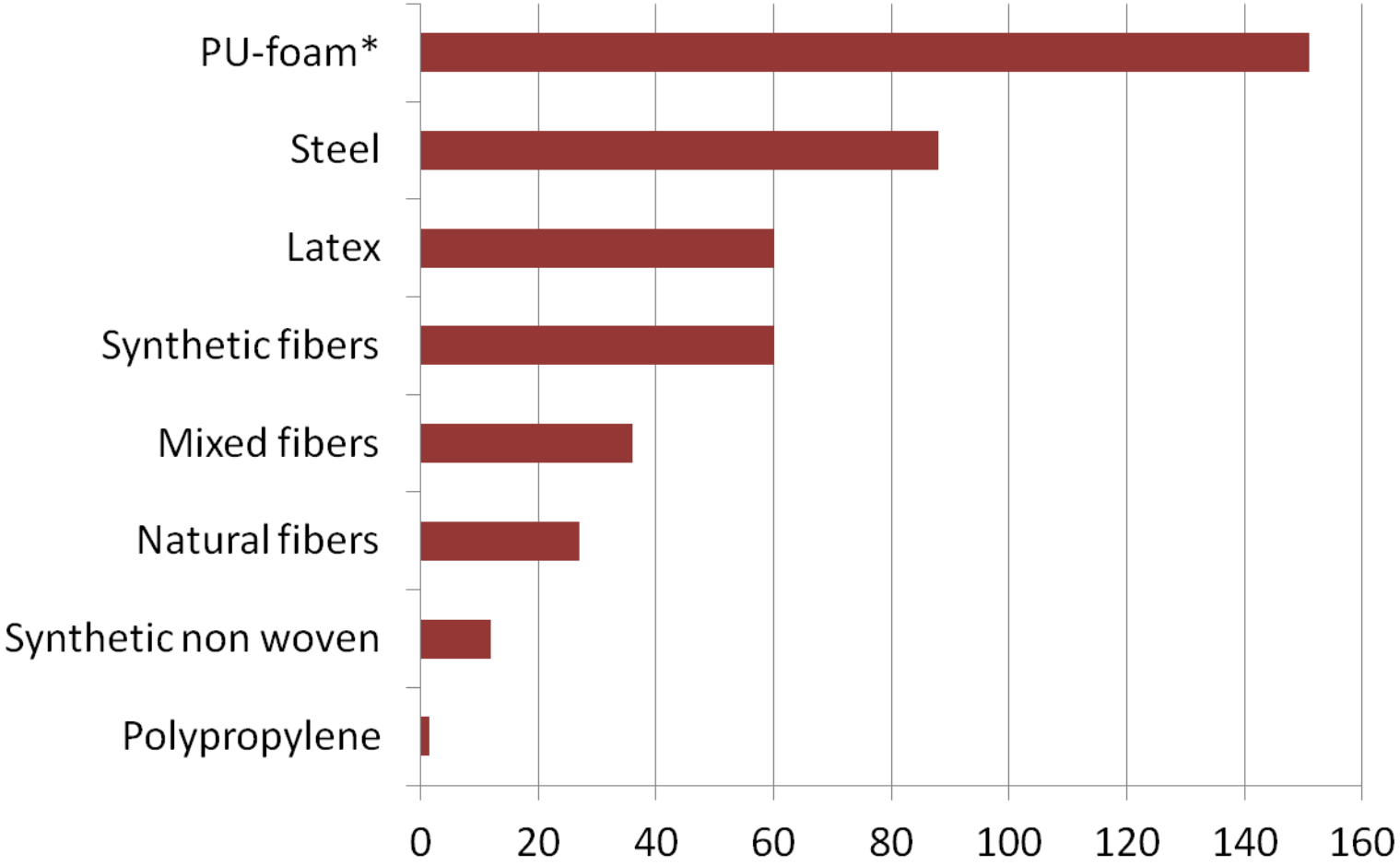
- Global energy demand is expected to increase by 45 % by 2030.
  80 % of the 2030 energy production will still be based on fossil fuels.

- The world economy has no other option than to move towards a "circular economy" in which material recycling and resource efficiency are the fundamental building blocks. Waste prevention and elimination of landfill are key instruments of the process towards the circular economy.

- The current EU solid waste treatment performance has an annual improvement potential, based on currently available technologies, of 114 million tons CO_2 equivalent. This represents a subsantial contribution to the global reduction of greenhouse gas emissions and hence to the climate change containment.

3. EoL-Material Mix & Annual Volumes

(based on 30 mio units/yr – 45% spring / 45% PU foam / 10% latex



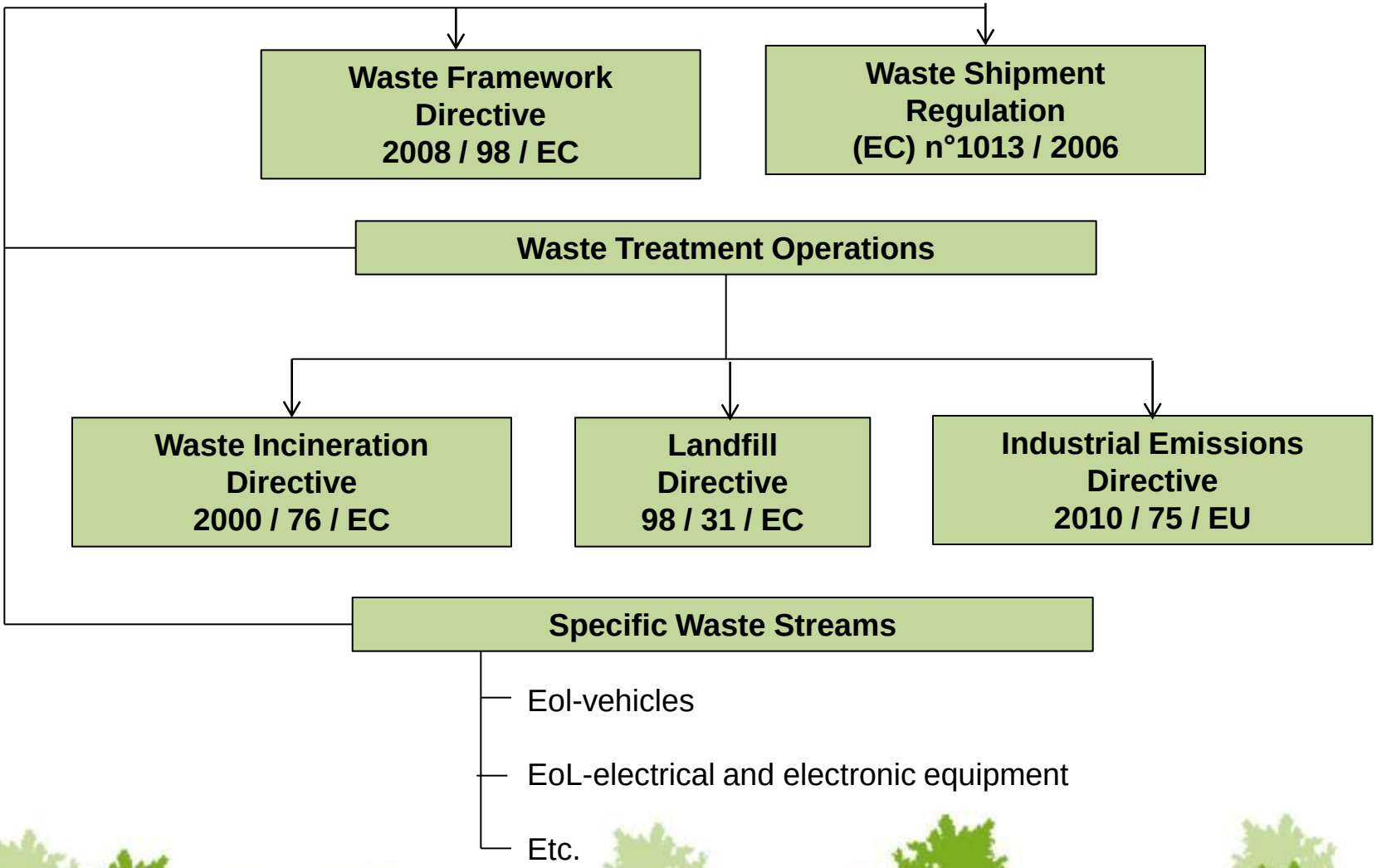
* To be amalgamated with approx. 500 kTons/yr upholstered furniture EoL-PU-foam

4. Core Material Characteristics

- Steel is incompatible with any of the mattress recycling/recovery options. Spring mattresses must be dismantled to allow the springs to be separated from the other materials. EoL-springs can not be restored and are to be integrated in the approx. 100 million ton “old metals” recycling market used in the production of virgin steel.

- PU-foam and latex are both thermoset materials. The EoL material can not be melted and can not be restored. Any second generation application for the EoL material must have less demanding functionality requirements.

5. EU-Waste Legislation Framework



5. EU-waste treatment directives

5.1. Landfill

- Integrated in the landfill directive is a phase-out plan for biodegradable waste. 2014 volume target is a reduction of landfilled biodegradable waste to 35 % of the 1995 volume.

- Expectation is that the 2013 landfill directive update will also integrate a phase-out plan for high caloric waste (a.o. mattresses and upholstered furniture).

- Some member states have already banned landfill of high caloric waste in their national legislation. This is the case for Austria, Belgium, Denmark, Germany, Italy, Norway, Sweden and Switzerland. Finland is currently implementing such ban with a transition period until 2016.

5.2. EU Waste treatment terminology / hierarchy

Hierarchy	Definition
1. Prevention	Self-explanatory
2. Preparing for re-use	Any operation allowing products or components to be re-used for the same purpose.
3. Recycling	Any re-processing operation allowing waste materials to be re-used for the original or other purposes excluding energy recovery or re-processing into fuels.
4. Recovery	Any operation allowing waste to substitute other material in a particular function including energy recovery and conversion to fuel.
5. Disposal	All others.

5.3. Extended Producer Responsability

- Member states decide on extended producer responsibility.
- Extended producer responsibility must take technical feasibility, economic viability and overall SHE impact into account.
- ‘Polluter pays’ principle applies (current or previous owner) but member states may decide cost to be borne by producers / distributors.

5.4. EU Strategy and Plans

- Waste prevention and landfill elimination are top priorities.
- Preferences on recycling / recovery technologies are very member state / region dependant.
- Waste prevention programs and targets 2014 – 2020 to be submitted by all member states no later than december 2013.

6. National legislation status

FRANCE

- Extended producer responsibility legislation in place since early 2012.
- Eco-Mobilier, a non-profit organisation established by a consortium of manufacturers and retailers, will handle the collection and treatment of all EoL residential furniture and bedding products. Operations were started early 2013.
- 2015 performance targets are 20% landfill / 35% incineration / 45% recycling

6. National legislation status

BELGIUM

- Extended producer responsibility preparatory discussions for Flanders region in final stage. Legislation to be expected latest 2014 – will most probably expand to other regions.
- Targets EoL – mattress recycling only.
- Different scenario's still under consideration.

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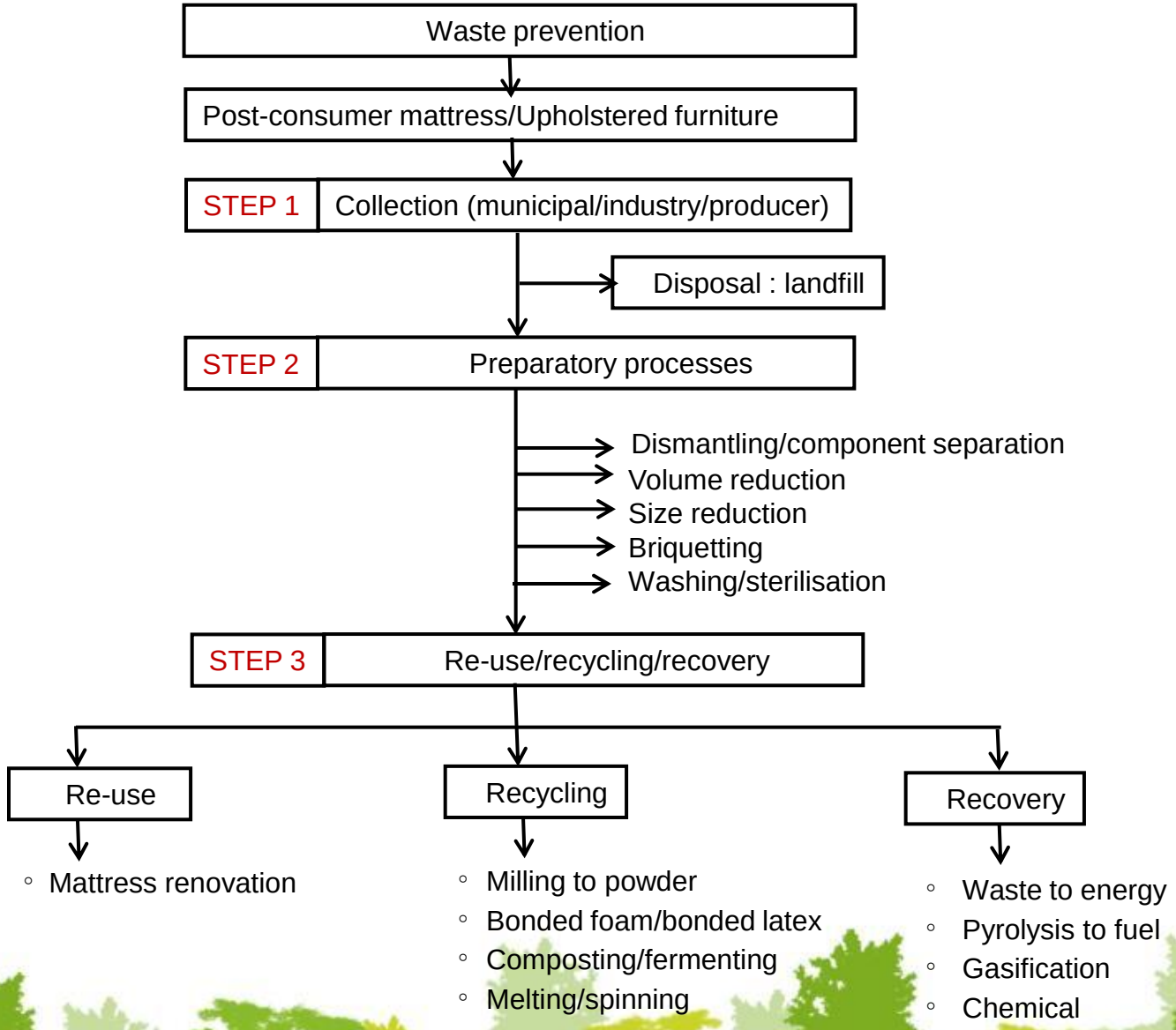
ITALY / SPAIN / U.K.

- Extended producer responsibility discussions in early stage.

7. EoL Process description & Options



8. The options

8.1 Waste prevention

- Bring mattress thickness in line with objective technical requirement.
- Improve spring / foam / latex longterm durability to extend usable life-time.
- For PU foam and latex find optimal balance between density, functionality and durability.
- Design for minimum trim % (foam).
- Strive for homogeneous cover architecture (all natural or all synthetic).
- Design for maximum use of recycled materials.

8.2 Re-use / Mattress renovation

- US market only.
- Approx. 50 active mattress renovators.
- 1 Billion $ market.
- Renovation depth & technology very unclear, commercial policy considered fraudulent.
- Re-use technology and market do not currently exist in Europe and this should not change.

8.3. Recycling (high volume options only)

8.3.1. Base material for bonded foam / latex

- Mature technology but unavoidable tolerances on key properties limit marketability in high volume applications.
- Minimum density (> 40 kg/m³) is an important barrier in markets where weight reduction is key.
- Current market is exclusively supplied with production trim foam / latex. Production trim percentage for PU foam is 20 to 25%, for latex 8 to 12%.
- Global bonded foam / latex market potential is limited and can not absorb additional volumes of trim (production or EoL) foam.

The global bonded foam / latex market

- Bonded foam / latex is produced in square and round blocks and moulded parts in densities between 40 and 400 kg/m³.
- Global market is estimated at 1.000 Ktons of which moulding is less than 3%.
- The market has gone through substantial geographical migration in recent years but is globally not expanding. Europe accounts for less than 10%.
- 65% of the market is for carpet underlay with a balance between renovation and new construction projects. US market has shrunk by 300 Ktons over the last 5 years by a combination of the real estate crisis and, mainly, a consumer preference shift to hard flooring. The US carpet underlay industry uses partly EoL bonded foam / latex when trim prices are high. Carpet underlay markets in the UK, Australia and New Zealand are growing.
- Other applications are mainly in acoustics and in energy absorption (packaging, hard flooring, shockpads etc.)
- There are currently no other products / applications in the pipeline that could potentially boost the market on a sustainable business.

8.3.2 Composting / fermenting

- Applies to the homogeneous natural fiber based fraction of the EoL mattress i.e. cotton, viscose, wool etc.

- Composting is an aerobic process, fermentation is anaerobic. Both processes convert biodegradable waste into humus in a 3 to 6 weeks process cycle, not requiring any energy or chemical input. Greenhouse gases generated by the processes are captured and converted to energy.

- Material needs to be flocked for process input.

- Potential is limited because of the rather long cycle time and because of the size / seasonality of the humus market. Existing industrial facilities are underutilised.

8.3.3 Remelting / extrusion

- Applies to the homogeneous synthetic fiber based fraction of the EoL mattress i.e. ticking, wadding, gitter, pockets, etc.
- Materials are seperated by chemical nature, remelted, extruded, spinned, weaved or knitted.
- The recycled material is of good quality but color and brightness are slighty impacted. Process cost is not different from virgin material.
- The presence of chemical biocides and anti-staining agents represents a serious SHE-risk and prohibits the industrial development of the technology. This can be resolved by the use of encapsulated bacteria based biocides and anti-staining agents which only recently became availale on the market.

8.4 Recovery options

8.4.1 Waste to Energy (PU-foam and Latex mattresses)

- Mature technology, technically and environmentally proven to be safe.
- Vast network of waste to energy facilities in most member states. More than 400 plants operational, converting 80 million tons into 35 GWh electrical power and 65 GWh heat.
- Political acceptance is very country dependant.
- No need for preparatory processes.
- The process can handle all EoL mattress materials except steel.
- The process is a net saver of greenhouse gas emissions e.g. Its CO_2 – equivalent emissions are lower than those that would be emitted to produce the same quantity of power and/or heat based on the EU power and heat mix.

8.4.2 Gasification (PU-foam and Latex mattresses)

- Process converts mixed plastics shredder residue into synthesis gas (CO / H2 / CH4). This is well-known chemistry but was industrially very complex and capital intensive.
- Ecoloop, part of Xella – Germany's largest building materials group, has renovated the process by introducing novel chemistry / technology using air as the main reactant and lime as a catalyst and scavenger for potential pollutants such as halogens, dioxine, etc.
- Ecoloop has built a 32 MW pilot plant in Ebingerode, near Hannover in Germany, which went into full operation in the last quarter of 2012 (Capex 30m €).
- Ecoloop claims exceptionally high thermal efficiency (> 80%), an emission free process, cost below fossil fuels and low capital intensity (<1m €/MW).
- Process stability, yields and environmental performances are still to be demonstrated on a sustainable basis. This will take until end 2013.
- Synthesis gas can be used as a fuel replacing natural gas, can be converted to electrical power or can be used as a base chemical.
- The process can handle all EoL – mattress materials except steel. The only preparation required would be to cut the foam or latex mattresses into pieces of maximum 30 x 30 cm.

8.4.3 Chemical recovery (PU-foam mattresses only)

- All chemical recovery methods require an homogeneous input stream to deliver a usable recyclate.
- Acidolysis is the only commercially available method that converts PU foam into a “secondary” polyol that can be re-used in prime foam production provided homogeneity conditions are met.
- EoL foam may contain additives or blowing agents that today are grey or blacklisted. These will fully or partly transfer into the recovered product and would require extra (expensive) processing to eliminate.
- Production trim in single market foaming plants could deliver homogeneous input streams but the number of foaming plants in such category is limited.
- Selection of certain mattress types from the EoL input streams could also create niche opportunities for acidolysis.
- However the material balance of the acidolysis process is very unfavourable i.e. the recovery of 1 ton EoL foam requires 1 ton of prime polyol. The resulting secondary polyol must be diluted with prime polyol by a factor 4 in order to fit for prime foam production.

8.5 Landfill

- Regulated by directive 1999 / 31 / EG and implementation very member state dependant.
- Allows shortest transport distances.
- Biodegradation is very slow.
- Gate fee ranging 20 – 100 €/Ton)
- Politically blacklisted at EU and most member states.
- Phase-out much slower than expected. 38% of all EU – solid municipal waste is still landfilled.

9. Outlook

- Landfill phase-out for high caloric waste is expected to be completed by 2018 – 2020.
- EU will exercise major pressure on waste prevention.
- More member states will establish EPR legislation with substantial risk of inconsistency.

10. Economics

Cost Items*

	€/ton
• Selective collection	65 – 90
• Dismantling	400 – 800
• Baling	100 – 200
• Shreddering	50 – 75
• Gate fee (recovery)	50 – 150

Income Items

• Steel	200 – 250
• Foam / Latex	150 – 200
• Fibers	50

* Fixed cost ECO-organism not considered

11. Conclusions

- No unique solution available.
- Recovery: crucial element of the EoL-treatment portfolio.
- No large volume technologies / applications in the development pipeline except Ecoloop – gasification.
- Current recyclates market unable to absorb EoL-volumes except steel.
- Waste prevention will impact product diversity and market value.
- Selective collection and dismantling have doubtfull Eco- and HS&E performance and are expensive.
- EPR-cost re-charge to the consumer will become an element of competition.

Thank you for your attention!