# Optimal allocation of green industrial waste

## Objectives and methods
- Proposing potential applications for three waste streams of a factory processing edible oils
  - Detailed composition of each waste
  - Review of the literature
- Analyzing the legal compliance and the environmental aspects of these applications
  - Examination of the Swiss waste legislation
  - Material and energy fluxes analyses
- Finding an environmentally optimal valorization alternative for each of the waste streams
  - Multi-criteria analyses

## Origin & description

<table>
<thead>
<tr>
<th>Waste Stream</th>
<th>Description</th>
<th>Proposed solutions</th>
<th>Results of multi-criteria analyses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spent bleaching earth</td>
<td>• Clay material used as a filter for bleaching and stabilizing crude oils (34%) • Soaked with oils and fats (3%) • High worthless mineral (ashes) content (32%) • High specific surface • Self-ignition hazard • Special waste subject to restrictive laws and requiring specific precautions</td>
<td>Burning for energy (fluidized bed combustion)</td>
<td>Material and energy fluxes: The ashes serve as the fluidized bed; air emissions: Direct burning: maximal efficiency</td>
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<tr>
<td>Soapstock</td>
<td>• Resulting from an alkali treatment of crude oils • Mixture of saponified fatty acids, water and impurities • Relatively low mineral content (3%) • Energy-rich compound • Harmless waste</td>
<td>Oil extraction (soapstock splitting to recover the free fatty acids)</td>
<td>Material and energy fluxes: Strong consumption of base and acid, ending as secondary waste; some energy inputs; biogas as by-product; Air emissions: Good quality of recovered oil, with many applications; high added value</td>
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<tr>
<td>Waste sunflower oil</td>
<td>• Refined sunflower oil used to clean the pipes • Quality nearly identical to pure oil • Very low levels of impurities (&lt;0.01%) and free fatty acids • Energy-rich compound • Harmless waste</td>
<td>Burning for energy (combined heat and power)</td>
<td>Material and energy fluxes: Virtually no inputs; air emissions: Direct burning: simplest and most effective way to recover the energy</td>
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</tbody>
</table>

## Conclusions
- All the waste streams have potential new uses that are both legally compliant and environmentally acceptable, in particular in the bioenergy sector
- Embodied energy (transformation, transportation, etc.) must be considered in the environmental assessment

## Recommended solutions
- Spent bleaching earth: pressure extraction of oils (the mineral fraction is landfilled)
- Soapstock: anaerobic digestion
- Waste sunflower oil: burning for energy

## Simplified process scheme and waste streams of the factory

### Origin & description
- Details, flowcharts

### Results of multi-criteria analyses
- Material and energy fluxes
  - 2.1 The ashes serve as the fluidized bed; air emissions: Direct burning: maximal efficiency
  - 1.9 No material inputs; very low energy inputs: Straightforward method but low recovery yield (50%)
  - 1.8 Base required; high pressure to maintain (autoclave): Rather simple method for a high recovery yield (close to 90%)
  - 2.3 Solvent handling is complex and possibly dangerous; heating needed to recycle the solvent: High recovery yield (90%) but safe facilities necessary
  - 2.1 Virtually no inputs (except heating); biomass production; air emissions: Simple, but mineral fraction deposits and has to be removed
  - 2.0 Strong consumption of base and acid, ending as secondary waste; some energy inputs; biogas as by-product: Good quality of recovered oil, with many applications; high added value
  - 1.6 Virtually no inputs (except heating); biomass production; air emissions: Few residues; expected to increase the overall methane yield of the digester; low added value
  - 1.6 Virtually no inputs; air emissions: Direct burning: simplest and most effective way to recover the energy
  - 1.9 Energy inputs for the processing steps; methanol needed for the reaction; air emissions: Lower efficiency but high added value (favorable policies)
  - 1.9 Virtually no inputs (except heating); biomass production; air emissions: Intermediate steps decrease the recovery yield; no use of the oil specificity; low added value
  - 1.6 Virtually no inputs: Fat-rich compound; high added value but strict requirements
  - Depend on the end application: Biodegradable; growing market

### Full report
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