In the current versions of the Renewable Energy Directive (RED) and the Fuel Quality Directive (FQD), biofuels produced from residues and wastes are promoted by counting double toward the targets of the directives (e.g. 10% share of renewable energy in transport) and by assigning zero GHG emissions from upstream operations. However, direct and indirect environmental and economic impacts of an increased use of wastes and residues for bioenergy implementation must be assessed, including also the analysis of their alternative uses.

Contact:
L. Marelli
European Commission • JRC • Institute for Energy and Transport
Email: luisa.marelli@jrc.ec.europa.eu

Second-generation biofuels and bioenergy from wastes and residues are currently receiving much attention as they are seen as a solution to many of the sustainability issues posed by crop-based biofuels. However, an assessment of their environmental impact is essential in order to avoid promoting feedstock materials that may have unexpected negative environmental consequences. The actual environmental impacts caused by an additional demand for residues for bioenergy sector largely depend on the origin and type of the feedstock, and in many cases this impact may be significant. Therefore, a detailed analysis of the most commonly used residues for bioenergy implementation is necessary in order to promote only the best practices and to minimise negative effects. For a complete picture of the sustainability of bioenergy it is necessary to expand the system boundaries and to analyse also the alternative uses for biomass residues.

The JRC is carrying out an assessment of the direct and indirect environmental effects for specific materials relevant to the EU bioenergy market to produce power, heat and transportation fuels. The analysed materials are currently: cereal straws, feedlot manures, pruning residues and residues from forestry logging operations.

https://ec.europa.eu/jrc
Evaluating the direct GHG emissions associated to the supply chain of bioenergy from residues, wastes and lignocellulosic feedstocks is quite straightforward following the methodology set in the RED Directive (2009/28/EC). The results of JRC calculations indicate that most of the pathways will generally achieve GHG emissions savings above 50% compared to fossil fuels.

In the RED methodology, the alternative (i.e. non-bioenergy) uses of biomass residues are excluded from the analysis. The following elements are essential to arrive at sound policy conclusions and must be considered:

- Non-bioenergy uses of biomass wastes and residues considered for bioenergy (baseline use).
- Effects of an increased removal from the original environment (removal effects).
- Effects of subtraction from other industries (displacement effects).

This analysis is performed by expanding the system boundaries (to include what would have happened to that biomass feedstock if it had not been used for energy production) and move from a purely attributional methodology to a more consequential one.

**Figure 1:** Direct GHG emissions associated with the supply chain of various bioenergy pathways from residues and wastes

**Figure 2:** JRC Qualitative assessment of environmental impacts caused by the use of biomass residues for energy compared to baseline uses

<table>
<thead>
<tr>
<th>(Baselines= left on soil except prunings)</th>
<th>Total GHG emissions compared to fossil fuels</th>
<th>SOC</th>
<th>Nutrients Pool</th>
<th>Soil health/fertility</th>
<th>N₂O, CH₄</th>
<th>Pests, diseases, odours</th>
<th>Bio-diversity</th>
<th>Water</th>
<th>Displacement effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straw</td>
<td>☺☺☺☺</td>
<td>☻☺☺</td>
<td>☻☺☺☺</td>
<td>☻☺☺☺</td>
<td>☻☺☺☺</td>
<td>☻☺☺☺</td>
<td>☻☺☺☺</td>
<td>☻☺☺☺</td>
<td>☻☺☺☺</td>
</tr>
<tr>
<td>Pruning residues</td>
<td>☻☺☺☺</td>
<td>☻☺☺</td>
<td>☻☺☺☺</td>
<td>☻☺☺☺</td>
<td>☻☺☺☺</td>
<td>☻☺☺☺</td>
<td>☻☺☺</td>
<td>☻☺☺☺</td>
<td>☻☺☺☺</td>
</tr>
<tr>
<td>Manure</td>
<td>☻☺☺</td>
<td>☻☺☺</td>
<td>☻☺☺☺</td>
<td>☻☺☺☺</td>
<td>☻☺☺☺</td>
<td>☻☺☺☺</td>
<td>☻☺☺</td>
<td>☻☺☺☺</td>
<td>☻☺☺☺</td>
</tr>
<tr>
<td>Forest residues</td>
<td>Short term: ☻☺☺</td>
<td>☻☺☺</td>
<td>☻☺☺☺</td>
<td>☻☺☺☺</td>
<td>☻☺☺☺</td>
<td>☻☺☺☺</td>
<td>☻☺☺</td>
<td>☻☺☺☺</td>
<td>☻☺☺☺</td>
</tr>
<tr>
<td></td>
<td>Long-term: ☻☺☺</td>
<td>☻☺☺</td>
<td>☻☺☺☺</td>
<td>☻☺☺☺</td>
<td>☻☺☺☺</td>
<td>☻☺☺☺</td>
<td>☻☺☺</td>
<td>☻☺☺☺</td>
<td>☻☺☺☺</td>
</tr>
</tbody>
</table>

Notes:
- One neutral category (☺)
- Three levels of benefits: Low (☺); Medium (☺☺); High (☺☺☺)
- Three levels of negative effects: Low (☺); Medium (☺☺); High (☺☺☺)
- Colour codes: red= significant negative impacts; green= significant benefits; orange: low benefits or negative impacts