



WWF

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# SMART USE OF RESIDUES

Exploring the factors affecting the sustainable extraction rate of agricultural residues for advanced biofuels

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WWF’s mission is to stop the degradation of the planet’s natural environment and to build a future in which humans live in harmony with nature, by: conserving the world’s biological diversity, ensuring that the use of renewable natural resources is sustainable, and promoting the reduction of pollution and wasteful consumption.



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# INTRODUCTION

*Since global food demand is projected to increase and land availability is limited, making smart use of resources has become a priority*

The growth of biofuel production leads to concerns about sustainability, particularly given the need to meet growing global food demand<sup>1</sup>. When choosing advanced biofuels that use alternative feedstocks such as agricultural residues and wastes that do not compete

for productive land resources or with food production, their potential greenhouse gas savings make them a promising alternative to contribute to the decarbonisation of the transport sector. Ambitious EU action on advanced biofuels based on sound scientific evidence of its advantages, would also help relieve concerns over possible indirect land use change effects of biofuels.

In 2009, the EU renewable energy Directive 2009/28/EC (the 'RED') established a target to source 20% of the EU's energy from renewable energy by 2020, sub-divided into binding Member State targets. The Directive also established a 10% renewable energy obligation in the transport sector, which, according to the National Renewable Energy Action Plans (NREAPs), will primarily be achieved through the use of biofuels. The consumption of biofuels in the EU has increased rapidly in recent years, reaching 10.7 million tons of oil equivalent (toe) of biodiesel and 2.9 million toe of bioethanol in 2010<sup>2</sup>. The feedstocks for these so-called 'conventional' biofuels are energy crops, such as oilseeds, starch or sugar crops.

Although crop residues have the advantage of not requiring additional land, residues are still integrated into the agricultural system as a physical and carbon resource. To develop a full picture of the potential of advanced biofuels, a sustainability assessment is needed. This assessment should determine what environmental effects could be induced through the removal of crop residues for biofuel production, and which policy recommendations might follow to ensure sustainable use.

*This paper represents an initial assessment, relying on the expanding field of research on advanced biofuels. The first part highlights the role of advanced biofuels in decarbonisation. The second part investigates the environmental impact of advanced biofuels, while the last part gives policy recommendations.*

*Use of residues and waste streams to produce advanced biofuels can play a crucial role in our global energy vision – 100% renewables by 2050*

## Advanced biofuels have a role in deep decarbonisation

While first plants to produce advanced biofuels are already under construction, the International Energy Agency<sup>3</sup> **foresees a considerable number planned in the next few years, followed by rapid expansion from 2020. Recent research<sup>4</sup> states that through the sustainable use of agricultural wastes** it would be possible to replace around half of global gasoline consumption by 2030.

The European Commission views advanced biofuels as having an important role in its roadmap to decarbonising the economy by 80 to 95% in 2050<sup>5</sup>. **Within the Commission's 2050 Energy Roadmap, advanced biofuels** get special attention: "The market uptake of new bioenergy which reduces demand for land necessary for food production and which increases the net greenhouse gas savings (e.g. biofuels based on waste, algae, forest residues), should continue to be promoted." For WWF, use of residues and waste streams to produce advanced biofuels can play a crucial role in the global WWF energy vision – 100% renewables by 2050, in particular within the sectors of high temperature processes in industries, aviation, shipping and heavy duty trucks<sup>6</sup>.

1 Examples are: <http://www.reuters.com/article/2011/07/08/us-eu-biofuels-idUSTRE76726B20110708>  
<http://uk.reuters.com/article/2012/05/02/uk-eu-biofuels-idUKBRE84115L20120502>

2 Biofuels barometer – Eurobserv'er – July 2011, [http://www.eurobserv-er.org/pdf/biofuels\\_2011.pdf](http://www.eurobserv-er.org/pdf/biofuels_2011.pdf)

3 IEA 2011: Technology Roadmap, Biofuels for transport; ([http://www.iea.org/papers/2011/Biofuels\\_Roadmap.pdf](http://www.iea.org/papers/2011/Biofuels_Roadmap.pdf))

4 Bloomberg New Energy Finance, 'Moving towards a next-generation ethanol economy,' January 2012.

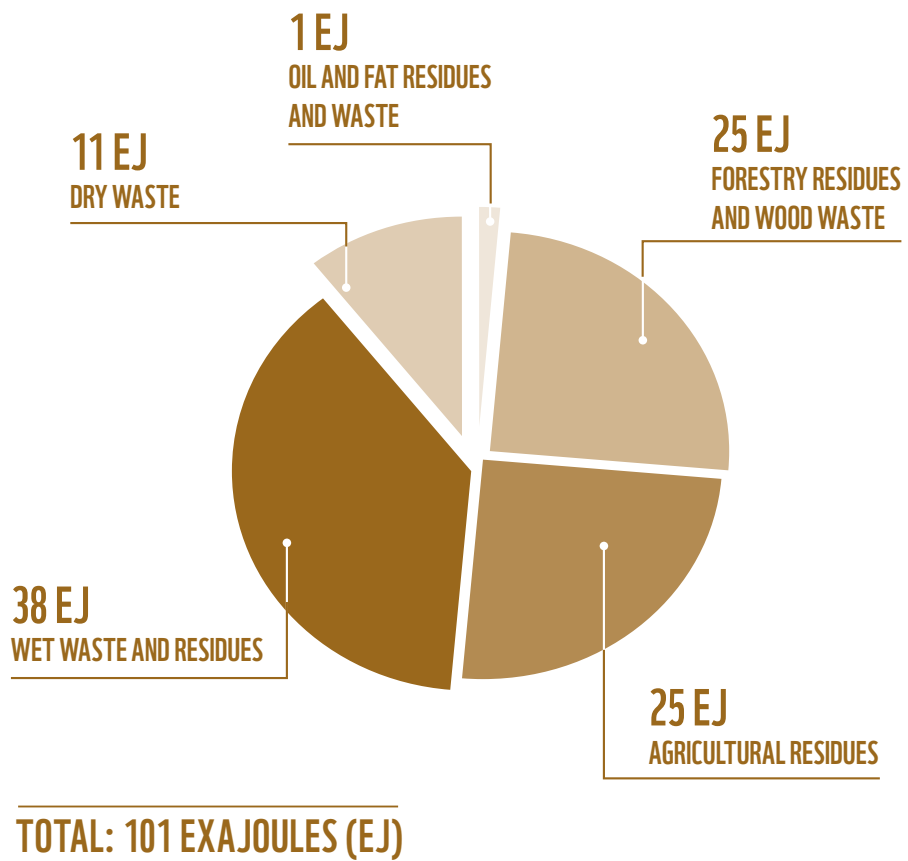
5 COM(2011) 112: Roadmap for moving to a competitive low-carbon economy in 2050

6 WWF 2011: Energy Vision – 100% Renewable Energy by 2050

### Advanced biofuels from agriculture residues in the WWF Energy vision for 2050

Within the global WWF Energy Vision – 100% Renewable Energy in 2050 – agriculture residues contribute 25 exajoules (EJ) of primary energy, accounting to around 25% of the total amount of primary energy from all residues used in 2050 (101 EJ). The report has based this number on the assumption that in OECD countries only 35% of the straw is available for energy purposes due to competing use as soil fertiliser, animal feed or animal breeding, and because of collection barriers.

*Sustainable residues and waste potential in five categories in primary energy. WWF Energy Report, 2011*



AGRICULTURAL RESIDUES  
COULD CONSTITUTE MORE THAN  
**25%**  
OF THE TOTAL AMOUNT OF PRIMARY  
ENERGY FROM ALL RESIDUES USED IN 2050





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Agricultural residues support biodiversity.

# ASSESSING THE RELEVANT FACTORS AND LIMITS FOR THE SUSTAINABLE USE OF AGRICULTURAL RESIDUES

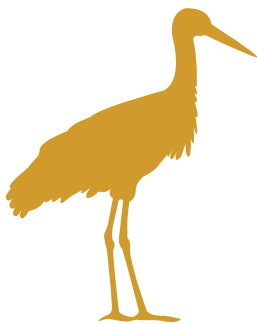
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The sustainability advantages of advanced biofuels have led them to be viewed as a “cleaner and greener” option, but any energy source produced at large scale, or without sufficient care, can have environmental impacts.

To date there has been little research into the potential environmental impacts of the use of residues as a feedstock. In particular, region-specific analysis of possible impacts and sustainable limits of extraction of residues of the field are lacking. A review of the existing potential studies about agriculture residues in Europe, carried out for this paper<sup>7</sup> shows that Europe has potential from agriculture residues, but it gives no clear guidance on the sustainable limit of extraction, as none

of the reviewed studies have taken into account the full picture on sustainability. Studies examining the potential of residue removal across the EU tend to assume what are generally considered to be conservative extraction rates.

This chapter highlights possible impacts of each aspect of sustainability for consideration, on the basis of a literature review. Further research on these factors should allow the definition of sustainable extraction rates that are the most appropriate to local conditions.



## **Biodiversity**

*The removal of agricultural residues may have impacts on biodiversity because of changed habitat functions like shelter, fodder source or nesting places.*

For several animal species, cereal fields and straw can serve as feeding grounds, nesting area, observatory perches or places of refuges against predators. Research has estimated that 50% of all species in Europe depend on agricultural habitats and, consequently, the major pressure affecting farmland biodiversity today relates to changes to traditional farming practices within the agricultural landscape. For below-ground fauna, organic matter is the main resource and habitat for soil life. Reducing the input of fresh organic matter in the system (i.e. stubble) will impact not only on the organisms living on the soil surface but also organisms in deeper soil layers. Changes in the attributes or quantity of the organic matter getting in the soil may have cascading effect on the whole soil-associated food web.

In this context the removal of agricultural residues such as straw for energy purposes is an additional step towards the intensification of agriculture. One has to keep in mind that a change in one condition can negatively affect farmland productivity and survival as well as soil life and soil health.

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<sup>7</sup> DBFZ, Öko-Institut e.V. 2011: Environmental impacts of the use of agricultural residues for advanced biofuel production, commissioned by WWF. unpublished



### **Soil organic matter**

*The export of agricultural residues from the field means a loss of organic material which influences the humus balance of the soil.*

Soil organic matter is also called “humus” and is formed by the whole dead substance representing all states of the decomposition process. It plays an important role:

- Humus is a carbon sink – it works as a reservoir that accumulates and stores some carbon-containing chemical compounds for an indefinite period
- Humus also improves soil structure, which is important for plant growth and to minimize erosion.

A removal of crop residues can lead to a decline of humus over time – with consequences for soil fertility and other soil functions. In addition to that, the current and future soil carbon pools and the potential foregone sequestration of carbon through the removal of agriculture residues are the key issues in order to protect the scarce resource of productive soils.



### **Water and erosion**

*The reduced soil coverage may lead to a change in the humidity regulation of the soil and reduced protection of evaporation and erosion due to wind and precipitation.*

Water naturally evaporates from soil. The agricultural residue mulch forms a barrier that slows down evaporation while allowing rainfall to soak down into the soil. Mulch covering helps reduce water evaporation in dry sites, especially under high temperatures and low humidity. Agricultural use of land is always accompanied by soil erosion by water and wind and therefore mulch is also important to prevent soil erosion.



### **Greenhouse gas emissions**

*Greenhouse gas emissions might occur through soil carbon changes when extracting residues, as well as emissions through the use of fertilisers and diesel caused by straw removal.*

Soil carbon is the generic name for carbon held within the soil, primarily in association with its organic content. Soil carbon is the largest terrestrial pool of carbon.

The current greenhouse gas accounting system under the RED has not considered residues as having any greenhouse gas emissions until they leave the field on which they have been grown. However, there is a lack of scientific information demonstrating that agricultural residue removal does not lead to relevant amounts of CO<sub>2</sub> emissions. A differentiation between “traditional farming” and systems with residue extraction would be necessary.

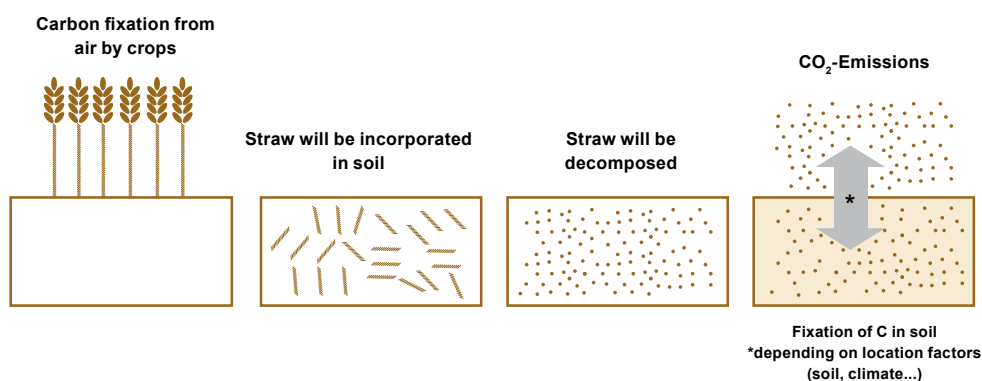


## Indirect land use change

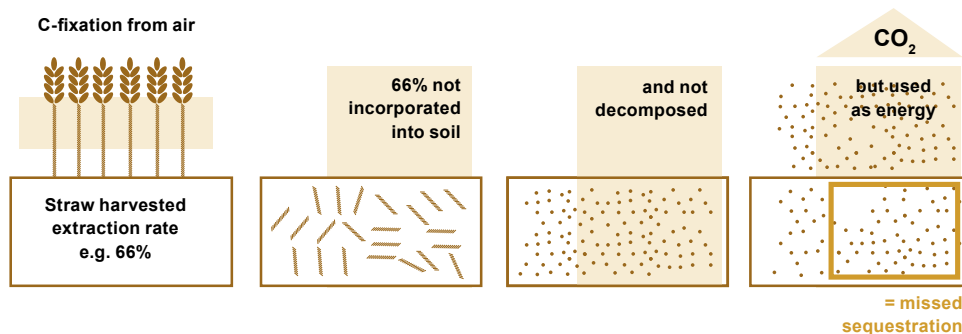
The indirect land use change impacts of biofuels, also known as ILUC, relates to the unintended consequence of releasing more carbon emissions due to land-use changes around the world induced by the expansion of croplands for ethanol or biodiesel production in response to the increased global demand for biofuels.

Advanced biofuels are based on the extraction of residues, and therefore are not yet considered to cause additional greenhouse gases emissions through indirect land use change<sup>8</sup>. Furthermore, shifting from conventional to advanced biofuels can provide a solution to tackling the ILUC problem, because both food and residues, with multiple uses including for energy, can be produced on the same land. This should be reflected in European policy to tackle ILUC<sup>9</sup>.

*Carbon cycle in agricultural systems without energy uses of straw*



*Carbon cycle in agricultural systems with energy uses of straw*



8 There are cases which might need a more differentiated consideration, when residue use for energy purposes is scaled up. A farmer can optimise the crop rotation system aiming to increase straw yields for energy purposes, but decreasing other harvest products. If the missing products were substituted from another area, and ILUC risk could occur.

9 2010 WWF European Policy Office response on the EC public consultation on indirect land use change



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Soil organic material is a carbon sink. It also improves soil structure.

# RECOMMENDATIONS

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WWF sees a set of measures necessary to wean transport from fossil fuels: these include modal shift, efficiency, electrification, and advanced biofuels.

As with any energy technology, all of the relevant sustainability considerations of advanced biofuels should be taken into account to guide scale-up.

To date there is no uniform approach in the literature to define sustainable extraction rates of agricultural residues to avoid or minimise environmental impacts. In estimating that half of gasoline demand could be met by biofuels from residues, Bloomberg New Energy Finance<sup>10</sup> **assumed that only 17.5% of the residues** would be taken from the field for biofuels. The literature review<sup>11</sup> carried out by the German Biomass Research Centre about sustainable potentials of agriculture residues in Europe has shown a range from 20 to 40% of recommended extraction, though these studies lack a full consideration of the sustainability aspects noted here.

Sustainable extraction rates are dependent on water and soil conditions as well as on the regional climate. A better understanding of these factors is needed to draw the line between sustainable and unsustainable uses of agriculture residues on a regional basis. This holds true for the following aspects in particular.

- 1. Biodiversity:** The impact of agriculture residues removal on biodiversity needs to be investigated, in particular the short, mid, and long-term effects on microflora and fauna in soils are missing any details.
- 2. Soil organic matter:** In order to identify the sustainable amount of agricultural residues (especially straw), which could be extracted, regionalised and site-specific information about soil carbon is necessary for all European countries. Additionally an adequate methodological standard for Europe (e.g. humus balancing tools) has to be created to realise the goal of soil organic matter maintenance.
- 3. Greenhouse gas emissions:** The current framework for the accounting of residues is set as creating no greenhouse gas emissions up to the collection of the residues. This needs to be based on sound scientific evidence in order not to risk influencing soil fertility and health negatively. For that reason additional methodological details of the right reference system and the extension of systems boundaries for the GHG balance of agriculture residues should be discussed and adjusted in the current approach.
- 4. Evaporation and erosion risk:** This literature review indicates that the amount of straw needed for erosion protection and humidity regulation would not exceed the amount needed for soil organic matter maintenance (based on average assumptions for Europe). Quantitative conclusions on the impacts of evapotranspiration and soil erosion due to straw removal are not available. Further research to gain site-specific information about the relation between straw extraction and the related effects on erosion and evaporation is needed.

**In general, the discussion on a sustainable use of crop residues for biofuel production cannot be discussed independently of the overall question on the future orientation of agriculture production systems and the functions of our soils, e.g. whether agricultural production should lead to an increase of sequestration of carbon. That issue is well beyond the scope of a discussion of biofuels alone.**

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<sup>10</sup> Bloomberg New Energy Finance, op cit.

<sup>11</sup> DBFZ, Öko-Institut e.V. 2011: Environmental impacts of the use of agricultural residues for advanced biofuel production, commissioned by WWF. unpublished

# Agricultural residues for advanced biofuels in figures

100%  
RECYCLED



## 14.1 MILLION

Domestic production in 2012 amounts to 14.1 million tons of bioethanol and biodiesel raising environmental concerns

## 2020

Advanced biofuels are expected to expand rapidly from 2020



## 2050

For WWF, use of residues for advanced biofuels can play a crucial role in reaching 100% of renewable energy by 2050

## 20 - 40%

Agricultural residues which might be sustainably extracted in Europe, according to WWF's literature review



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