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Project No. 1574 / DBI02002

Title Guidelines for sustainability certification of pyrolysis oil

Date April 2013

Prepared for DBI project “Sustainable Import of Pyrolysis Oil”
Colophon

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This report is a result of the project ‘Import sustainable pyrolysis oil for chemicals and energy production in the Netherlands’, supported by NL Agency.
# TABLE OF CONTENTS

1 **INTRODUCTION**

1.1 Background 1  
1.2 This report 1  

2 **ROADMAP FOR PYROLYSIS OIL CERTIFICATION** 2  

2.1 Step 1: selection of a certification scheme 2  
2.2 Step 2: self assessment 2  
2.3 Step 3: selection of a certification body for independent verification 3  
2.4 Step 4: the certification process 3  

3 **APPLICATION OF RED CRITERIA TO PYROLYSIS OIL** 5  

3.1 Introduction 5  
3.1.1 Sustainability criteria of the RED 5  
3.1.2 Sustainability criteria beyond RED 5  
3.1.3 Why meeting the sustainability requirements of the RED and beyond? 6  
3.1.4 How to comply with the RED sustainability criteria? 6  
3.2 RED greenhouse gas emission saving calculation method 7  
3.2.1 Minimum greenhouse gas emission savings 7  
3.2.2 Selection of emission reduction calculation method 8  
3.2.3 Calculation of emissions 9  
3.2.4 Calculation of greenhouse gas emission savings 12  
3.3 Biodiversity 14  
3.4 Carbon stock 16  
3.5 Former peat land 17  
3.6 European agricultural legislation 19  
3.7 Conclusion 19  

4 **PYROLYSIS OIL CERTIFICATION** 20  

4.1 EU recognised biomass sustainability certification systems 20  
4.2 Description of relevant biomass certification systems 21  
4.2.1 ISCC 21  
4.2.2 RSB EU RED 22  
4.2.3 2BSvs 23  
4.2.4 RBSA 23  
4.2.5 NTA8080 23  
4.3 Summary and selection of certification systems 24
1 INTRODUCTION

1.1 Background

The Renewable Energy Directive (RED) imposes sustainability requirements on transport fuels and bioliquids that are used to meet renewable energy obligations and that are eligible for financial support (like SDE+). Furthermore, market players appreciate that the sustainable origin of biofuels and bioliquids is guaranteed, and – motivated by their corporate social responsibility, or risk management - could even expect a higher level of sustainability as described in voluntary biomass certification schemes.

Bioliquids are liquid fuels for energy purposes other than for transport, including electricity and heating and cooling, produced from biomass. This is an essential difference from biofuels that are defined as liquid or gaseous fuels for transport produced from biomass. Pyrolysis oil is one of the first – maybe the very first - second generation bioliquid that has reached commercial production and thus needs sustainability certification under RED. Most RED compliant certification schemes cater certification of sugar and starch crops for ethanol production and oil crops for biodiesel production. For this reason, there is a need for specific guidance for producers of second generation bioliquids that seek sustainability certification.

This report is part of the project ‘Import of sustainable pyrolysis oil for the production of chemicals and energy in the Netherlands’ funded under the Sustainable Biomass Import programme of NL Agency. The project focuses on the sustainable import of pyrolysis oil from Cartaya in Spain covering sustainability certification (following the Renewable Energy Directive and NTA8080), and the sustainability of the pyrolysis oil production and logistics. Based on the findings of this project, general guidelines for sustainability certification of pyrolysis oil are drawn up that can serve as a blue print for certification by biomass producers, pyrolysis plant owners, and end-users of pyrolysis oil. These guidelines are also useful for producers of other second generation bioliquids that seek sustainability certification.

1.2 This report

Chapter 2 provides a roadmap for pyrolysis oil certification. Where relevant reference is made to other parts of this report and to external sources. More detailed information on the sustainability requirements of the Renewable Energy Directive (RED) is provided in chapter 3. Finally, chapter 4 presents an assessment of the suitability of EC-approved voluntary sustainability schemes for pyrolysis oil certification that generally have sustainability requirements beyond the RED.

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1 Directive 2009/28/EC on the promotion of the use of energy from renewable sources.
2 ROADMAP FOR PYROLYSIS OIL CERTIFICATION

The process of pyrolysis oil certification consists of the following steps:
1. Selection of a certification scheme
2. Self assessment
3. Selection of a certification body for independent verification
4. The certification process

2.1 Step 1: Selection of a certification scheme

If pyrolysis oil is used for (subsidised) renewable energy generation or biofuels production, the oil should be certified according to a voluntary certification scheme recognised by the European Commission. All recognised schemes can be found on http://ec.europa.eu/energy/renewables/biofuels/sustainability_schemes_en.htm. In section 4.1 to 4.3 guidance is given on which certification schemes are suitable for pyrolysis oil production. The following questions are addressed:

- Is the system formally allowed to certify liquids from biomass other than sugar, starch and oil crops?
- Has practical experience been gained with (woody) biomass or bioliquids certification?
- Is the scheme fully operational: how many certificates have already been submitted?
- What schemes have the strongest sustainability criteria beyond RED?
- Is the scheme transparent and workable?

The guidance is based on the situation of March 2013. It is advisable to consult the EC website to check if there are any changes.

Forest certification systems like FSC and PEFC do not include a greenhouse gas savings calculation. Therefore FSC and PEFC certification alone is not sufficient to meet the sustainability requirement of the RED. Nevertheless it is an advantage to supply biomass from FSC or PEFC certified forests, as many sustainability requirements are met and the origin of the biomass is traceable.

2.2 Step 2: Self assessment

Before starting the certification process, it is advisable to perform a self assessment of the sustainability requirements. In chapter 3.2 further guidance is given on the calculation of the greenhouse gas reductions according to the RED. Furthermore, it is advised to check whether the biomass production meets the other sustainability criteria of the RED on biodiversity, carbon stocks and wetlands. More information is provided in sections 3.3 to 3.6. Finally, also the additional sustainability requirements of the selected certification scheme should be checked.

Biomass should not be only sustainable but also traceable. The biomass supplier should be able to provide proof of the origin of the biomass to the certification body.
biomass supplier does not know the origin of the biomass, no certification can take place. The biomass buyer does not necessarily need to know the origin of the biomass, it is sufficient if the supplier provides a transaction certificate that states the CO₂ emissions that occurred so far, i.e. during cultivation, harvest, possible sizing and transport. The owner of the conversion plant adds the CO₂-emissions from the process on the transaction certificate, such that the end-user can show that the minimum greenhouse gas emissions savings are met.

Based on the outcomes of the self-assessment, the necessary measures are taken. These measures can be taken on an administrative level, or they can be material. In addition, agreements with suppliers, buyers or other involved parties may be necessary. If the self-assessment has a positive outcome, the actual certification process can be started.

### 2.3 Step 3: selection of a certification body for independent verification

An independent third party, also called certification body or verifier, needs to perform the verification according to the requirements of the certification scheme. A list of accredited certification bodies can be found on the website of each scheme. The experience of the certification body with the scheme can be estimated by checking the amount of certificates that have been issued by the verifier. This information is made public on the website of the certification scheme.

The costs of the verification will mainly depend on the audit duration and the daily fee of the auditor. NTA8081 prescribes the audit duration for initial and recertification audits, for pre-audits and on-site audits, for producers, processors, traders and end users. For producers, the audit duration will also depend on the area of cultivation. See [http://www.sustainable-biomass.org/publicaties/3950](http://www.sustainable-biomass.org/publicaties/3950), section 6.3. This gives some certainty on the auditing duration. The audit costs also depend on the daily fee, therefore offers need to be requested from one or more certification bodies.

### 2.4 Step 4: the certification process

At the start of the certification process an initial audit is needed, and each year surveillance audits are performed. The audits consist of two stages (NEN 2012):

- Stage 1 concerns the preliminary investigation. The certification body assesses all the necessary documents, carries out a risk analysis and draws up the audit plan.
- Stage 2 concerns the assessment of the organization. The audit team of the certification body assesses the organization on site.

All actors in the supply chain from biomass production until the end user need to be certified.

- The *producer* is the organisation that produces the primary biomass or collects residual flows.
- The *processor* is the organisation that processes or converts the (primary) biomass, this is the pyrolysis plant.
- The *trader* is the organisation that trades in the biomass.
- The *end-user* is the organisation that uses the biomass for the generation of electricity and heat or production of biogas or biofuel.

In case of NTA8081 certification, storage facilities and transport companies do not need to be certified separately. The organisation - either the producer, processor, trader or end user - that owns or hires storage capacity or truck transport, is responsible for this part of the supply chain.

After the audit, the certification body will report its findings and possible major and minor non-conformities. Major non-conformities need to be corrected within a given time and solved before biomass can be certified. An overview of major non-conformities can be found in the description of the certification scheme. Minor non-conformities need to be solved before the next surveillance audit. If the audit has a positive result, a certificate can be provided that has a validity of five years. The certification scheme manager will request a fee for each certificate submitted, and/or a membership fee.
3 APPLICATION OF RED CRITERIA TO PYROLYSIS OIL

3.1 Introduction

3.1.1 Sustainability criteria of the RED

The Directive on the promotion of the use of energy from renewable sources (2009/28/EC), also known as the Renewable Energy Directive or simply RED has formulated the following sustainability requirements:

1. greenhouse gas savings meet certain minimum values;
2. biomass is not obtained from land with high biodiversity value;
3. biomass is not obtained from land with high carbon stock;
4. biomass is not obtained from land that was peat land;
5. Agricultural biomass raw materials cultivated in the Community and used for the production of biofuels and bioliquids meet certain European legislation.

These criteria are further investigated and applied to pyrolysis oil in sections 3.2 to 3.6.

Limited sustainability criteria for biomass from waste and residues

Biofuels and bioliquids produced from waste and residues, other than agricultural, aquaculture, fisheries and forestry residues, need only to fulfil the sustainability criteria related to greenhouse gas emission savings. This means that pyrolysis from secondary (processing) and tertiary (end of life) residues and wastes only need a GHG calculation.

3.1.2 Sustainability criteria beyond RED

The Renewable Energy Directive addresses only a limited number of sustainability criteria. The main reason is that it concerns obligatory sustainability requirements that are also applied in third countries. The European Commission and Member States are limited in the extent they can impose environmental and social criteria to third countries that go beyond what is internationally agreed on, as these countries could take the sustainability requirements as illegal trade barriers. Voluntary sustainability schemes, however, have the possibility to include additional sustainability requirements beyond the RED. Requirement could be related to:

- Biodiversity;
- soil, water and air quality;
- social well being of workers;
- well being of local communities;
- etc.

Many certification systems that can be used to meet the RED requirements include additional voluntary criteria. See Annex A for a presentation of the requirements of NTA8080, ISCC and RSB-RED. A comprehensive comparison can be found in Van Dam (2010). Also the report “How to select a biomass certification scheme” of NL Agency

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2 See RED article 17
gives an overview of certification systems. Chapter 4 provides a detailed assessment on certification schemes relevant for pyrolysis oil production and use.

3.1.3 **Why meeting the sustainability requirements of the RED and beyond?**

Bioliquids that meet the RED sustainability requirements can be used for:

- measuring compliance with the requirements of this Directive concerning national targets;
- measuring compliance with renewable energy obligations;
- eligibility for financial support for the consumption of biofuels and bioliquids.

Pyrolysis oil is a bioliquid, i.e. *a liquid fuel for energy purposes other than for transport, including electricity and heating and cooling produced from biomass*. If the use of pyrolysis oil is used for energy and supported by a feed in tariff or another support mechanism, like the Dutch SDE+, the pyrolysis oil must meet the sustainability requirements of the RED.

Producers and buyers of pyrolysis oil can mutually agree to supply pyrolysis oil that is certified according to more stringent sustainability criteria beyond the obligatory RED criteria. They could be motivated to do so for reasons like corporate social responsibility policies, marketing purposes, and/or to avoid possible questions from the public and NGOs. National governments can only impose compliance to the RED requirements and are not allowed to implement more stringent certification requirements in national law.

3.1.4 **How to comply with the RED sustainability criteria?**

Formally there are three ways to provide proof of sustainability:

1. by providing the relevant national authority with data, in compliance with requirements that the Member State has laid down (a ‘national system’)
2. by using a ‘voluntary scheme’ that the Commission has recognised for the purpose
3. in accordance with the terms of a bilateral or multilateral agreement concluded by the European Union with third countries.

**National systems**

The following countries have a national system in place or have the intention to implement a national system: Spain, Germany, Austria (provisional), Belgium, France, Italy, Portugal, United Kingdom and Sweden. Other countries like the Netherlands have no national system in place. Companies that put biofuels and bioliquids on the market in these countries can provide proof of sustainability by using a national system. The national systems can differ considerably, some countries have a system for recognition of national voluntary systems, others have a state owned national system. Some national

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3 Source: Comision National de Energia [of Spain] NE (2012), Analysis comparativo de los sistemas nacionales de sostenibilidad de los biocarburantes y bioliquidos en la UE
systems have the possibility to recognize other national systems, others do not offer this option.

It is very important to realise that these national systems are only applicable in the countries where the pyrolysis oil is used for energy generation or (mixed and) put on the market as transport fuel. In the Netherlands, for instance, no national system is in place so pyrolysis oil sustainability cannot be proven by other national schemes, if the end user is located in the Netherlands. Because of this important limitation, it has not been assessed in detail whether these national systems are able to deal with bioliquids like pyrolysis oil.

**EC recognised voluntary schemes**
At present the European Commission has acknowledged thirteen certification systems, of which five systems are applicable to all biomass in all regions. All member states are obliged to accept biofuels and bioliquids that are certified according to EU-recognised voluntary schemes, which is a considerable advantage over the national systems. The applicability of these schemes for pyrolysis oil certification is presented in more detail in chapter 4.

**Bilateral or multilateral agreements between EC and third countries**
So far, no bilateral or multilateral agreements have closed between the EC and third countries.

**Conclusion**
Only EC recognised voluntary schemes are a real option for pyrolysis oil that is going to be consumed in the Netherlands. Details of the different schemes are explored in chapter 4.

3.2 **RED greenhouse gas emission saving calculation method**

3.2.1 **Minimum greenhouse gas emission savings**
The directive 2009/28/EC on the promotion of the use of energy from renewable sources (further called RED) contains requirements to the minimum greenhouse gas emission saving from the use of biofuels and bioliquids. Only bioliquids and biofuels that meet these requirements will be taken into account to national targets, renewable energy obligations and be eligible for financial support for the consumption of biofuels and bioliquids. The following minimum greenhouse gas emission savings need to be realised (RED art. 17):

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4 March 2013
Thus, the moment the installation starts operation determines the minimum emission savings:

- If a pyrolysis plant starts operation before 1 January 2017
  - the emission savings should be 35%, and;
  - from 1 January 2017 on the emission savings should be 50%.

- If a pyrolysis plant starts operation after 1 January 2017:
  - the emission savings should be at least 50% and;
  - from 1 January 2018 the emission savings should be 60%.

### 3.2.2 Selection of emission reduction calculation method

The greenhouse gas emission savings from the use of biofuels and bioliquids shall be calculated in accordance with RED Article 19(1). Article 19(1) provides the following calculation methods:

(a) where a default value for greenhouse gas emission saving for the production pathway is laid down in Part A or B of Annex V and where the $e_i$ value for those biofuels or bioliquids calculated in accordance with point 7 of Part C of Annex V is equal to or less than zero, by using that default value;

(b) by using an actual value calculated in accordance with the methodology laid down in Part C of Annex V; or

(c) by using a value calculated as the sum of the factors of the formula referred to in point 1 of Part C of Annex V, where disaggregated default values in Part D or E of Annex V may be used for some factors, and actual values, calculated in accordance with the methodology laid down in Part C of Annex V, for all other factors.

**Calculation method (a) – use of default values**

Part A and B of Annex V of the RED contain typical and default values for a number of current and future biofuels that are not yet on the market. Point 7 of Part C of Annex V refers to the calculation method for net carbon emissions from land use change. Pyrolysis oil is not listed in Part A or B of Annex V, therefore calculation method (a) cannot be applied.
Calculation method (b) – calculation of actual value

Part C of Annex V presents a greenhouse emission calculation method according to the following equation:

\[ E = e_{cc} + e_l + e_p + e_{td} + e_u - e_{sca} - e_{ccs} - e_{ccr} - e_{ee'} \]

Where:

- \( E \) = total emissions from the use of the fuel;
- \( e_{cc} \) = emissions from the extraction or cultivation of raw materials;
- \( e_l \) = annualised emissions from carbon stock changes caused by land-use change;
- \( e_p \) = emissions from processing;
- \( e_{td} \) = emissions from transport and distribution;
- \( e_u \) = emissions from the fuel in use;
- \( e_{sca} \) = emission saving from soil carbon accumulation via improved agricultural management;
- \( e_{ccs} \) = emission saving from carbon capture and geological storage;
- \( e_{ccr} \) = emission saving from carbon capture and replacement; and
- \( e_{ee'} \) = emission saving from excess electricity from cogeneration.

Emissions from the manufacture of machinery and equipment shall not be taken into account.

This method could be applied to determine the greenhouse gas emission savings from pyrolysis oil production.

Calculation method (c) – combination of default values and actual values

This method is based on calculation method (b) but allows the use of disaggregated default values as presented in Part D of Annex V. These default values are however not useful for the calculation of greenhouse gas emission savings from pyrolysis oil.

It is concluded that calculation method (b) needs to be followed to calculate the greenhouse gas emission savings from pyrolysis oil.

Further guidance is provided in Annex V part C of the RED. Furthermore, RED art 19(7) indicated that annex V might be adapted with particular consideration given to, amongst others, the method of accounting for wastes and residues. So far, a Communication from the Commission on the practical implementation of the EU biofuels and bioliquids sustainability schema and on counting rules for biofuels (2010/C 160/02) has been published, of which section 3.3 and Annex II are relevant. The next section shows the actual calculations and further considerations.

3.2.3 Calculation of emissions

The method used will be calculation method b – calculation of actual values as was indicated in the previous paragraph. The formula used will therefore be:

\[ E = e_{cc} + e_l + e_p + e_{td} + e_u - e_{sca} - e_{ccs} - e_{ccr} - e_{ee'} \]
A number of emission factors do not need to be taken into consideration and can be set at zero. Below the relevance of the emissions factors for the emission savings calculation of pyrolysis oil is discussed.

**Emissions from the extraction or cultivation of raw materials**

*Emissions from the extraction or cultivation of raw materials, e_{cc}, shall include emissions from the extraction or cultivation process itself; the collection of raw materials; waste and leakages; and the production of chemicals or products used in extraction or cultivation (RED Annex V, part C, point 6).*

The emissions from cultivation of raw materials is usually negligible if woody biomass is used from existing forests, except in case of energy plantations. The emissions from the extraction of raw materials (harvesting and forwarding) need to be included in the greenhouse gas balance.

**Annualised emissions from carbon stock changes caused by land-use change**

*Annualised emissions from carbon stock changes caused by land-use change, e_{lc}, shall be calculated by dividing total emissions equally over 20 years. For the calculation of those emissions the following rule shall be applied […] (RED Annex V, part C, point 7).*

Land use change is not a topic if biomass is extracted from a forest that remains the status of a forest. Only if a forest is converted into e.g. agricultural land, this factor has to be taken into account. Usually there is no land-use change and $e_{lc} = 0 \text{ g CO}_2\text{-eq / MJ}$.

**Emissions from processing**

*Emissions from processing, e_{p}, shall include emissions from the processing itself: from waste and leakages; and from the production of chemicals or products used in processing (RED Annex V, part C, point 11).*

In the pyrolysis oil production process electricity, natural gas and chemicals are used. In addition, waste is created. In the greenhouse gas balance the emissions from processing need to be included.

**Emissions from transport and distribution**

*Emissions from transport and distribution, e_{tab} shall include emissions from the transport and storage of raw and semi-finished materials and from the storage and distribution of finished materials. Emissions from transport and distribution to be taken into account under point 6 shall not be covered by this point (RED Annex V, part C, point 12).*

Several emissions from transport and distribution can be identified. Examples are transport of raw material from the forests to the pyrolysis plant, shovel transport on the pyrolysis plant site and transport of pyrolysis oil to final customers. All these emissions need to be taken into account in the greenhouse gas balance.
Emissions from the fuel in use

Emissions from the fuel in use, \( e_u \), shall be taken to be zero for biofuels and bioliquids (RED annex V, part C, point 13).

The pyrolysis oil can be categorised as a biofuel or bioliquids. Therefore \( e_u = 0 \) g CO\(_2\)-eq / MJ.

Emission saving from soil carbon accumulation via improved agricultural management

In case of woody biomass no emission savings can be claimed from soil carbon accumulation via improved agricultural management: \( e_{sca} = 0 \) g CO\(_2\)-eq / MJ.

Emissions saving from carbon capture and geological storage

Emissions saving from carbon capture and geological storage, \( e_{ccs} \), that have not already been accounted for in \( e_p \), shall be limited to emissions avoided through the capture and sequestration of emitted CO\(_2\) directly related to the extraction, transport, processing and distribution of fuel. (RED Annex V, part C, point 14).

In general, pyrolysis oil production is not combined with carbon capture and geological storage, therefore: \( e_{ccs} = 0 \) g CO\(_2\)-eq/MJ.

Emission saving from carbon capture and replacement

Emission saving from carbon capture and replacement, \( e_{ccr} \), shall be limited to emissions avoided through the capture of CO\(_2\) of which the carbon originates from biomass and which is used to replace fossil-derived CO\(_2\) used in commercial products and services (RED Annex V, part C, point 15).

In case of pyrolysis oil for energy generation the emission savings from carbon capture and replacement are zero: \( e_{ccr} = 0 \) g CO\(_2\)-eq / MJ. Biobased products derived from pyrolysis oil, for instance the replacement of asphaltic bitumen with the lignin fraction of pyrolysis oil (biotumen), would qualify for carbon capture and replacement. The details of the emission reduction calculation is beyond the scope of this guidance document but could become relevant in the near future.

Emission saving from excess electricity from cogeneration

Emission saving from excess electricity from cogeneration, \( e_{ee} \), shall be taken into account in relation to the excess electricity produced by fuel production systems that use cogeneration except where the fuel used for the cogeneration is a co-product other than an agricultural crop residue (RED Annex V, part C, point 16).

In case of pyrolysis oil production, char and non-condensable pyrolysis gases are used for steam and electricity generation. RED Annex V, part C, point 16, however, indicates that emission savings from cogeneration are not taken into consideration when the co-product is not an agricultural residue. The emission saving from excess electricity from cogeneration is therefore set at zero: \( e_{ee} = 0 \) g CO\(_2\)-eq / MJ. Please note that the production of useful by-products like electricity and steam is taken into account in the emission calculation in the next section.
Conclusion
In the case of most pyrolysis plants the emission equation can be reduced to:

\[ E = e_{cc} + e_p + e_{td} \]

Where:
- \( E \) = greenhouse gas emissions from the use of pyrolysis oil;
- \( e_{cc} \) = emissions from the extraction or cultivation of raw materials;
- \( e_p \) = emissions from processing;
- \( e_{td} \) = emissions from transport and distribution.

3.2.4 Calculation of greenhouse gas emission savings

Allocation of emissions to co-products
Before calculating the emission savings, the allocation of emissions to possible co-products need to be determined. Greenhouse gas emissions shall be divided between the fuel or its intermediate product and the co-products in proportion to their energy content (determined by their lower heating value in case of c-products other than electricity) (RED Annex V, part C point 17)

In case of the pyrolysis oil production process co-products like steam and electricity are generated. Therefore emissions allocated to pyrolysis oil production (\( E_{PO} \)) should be calculated by the following formula:

\[ E_{PO} = \frac{Q_{PO}}{Q_{PO} + Q_W + Q_E} \times E \]

Where:
- \( E_{PO} \) = emission from the use of pyrolysis, after allocation of GHG emissions to the co-products heat and electricity;
- \( Q_{PO} \) = energy contained in pyrolysis oil per production hour of the pyrolysis plant (GJ/hour);
- \( Q_W \) = useful heat/steam produced per production hour of the pyrolysis plant (GJ/hour);
- \( Q_E \) = electricity production per production hour of the pyrolysis plant (GJ/hour);
- \( E \) = emissions from the use of pyrolysis oil without allocation of GHG emissions to co-products.

The unit GJ/hour can be replaced by another energy unit per time unit, as long as the units are the same for \( Q_{PO}, Q_W \) and \( Q_E \).
**Greenhouse gas emission savings**

The greenhouse gas emission savings are determined by use of the following formula of RED Annex V, part C, point 4.

\[ \text{SAVING} = \frac{(E_F - E_B)}{E_F} \]

Where:

- \( E_B \) = total emissions from the biofuel or bioliquids (equals \( E_{PO} \));
- \( E_F \) = total emissions from the fossil fuel comparator.

Following the methodology of the RED, standardised values can be used to compare the emission of the bioliquids with fossil electricity, heat or CHP production. RED Annex V, part C, point 19 gives the following fossil fuel comparators:

- \( E_F \) electricity = 91 g CO\(_2\)-eq/MJ
- \( E_F \) heat = 77 g CO\(_2\)-eq/MJ
- \( E_F \) cogeneration = 85 g CO\(_2\)-eq/MJ

The emission savings need to be higher than the minimum values of 35%, 50% and 60%, depending on the date of start-up of the operation as stated in RED article 17 and discussed in section 3.2.1.
3.3 Biodiversity

Biofuels and bioliquids shall not be made from raw material obtained from land with high biodiversity value, namely land that had one of the following statuses in or after January 2008, whether or not the land continues to have that status:

a. primary forest and other wooded land, namely forest and other wooded land of native species, where there is no clearly visible indication of human activity and the ecological processes are not significantly disturbed;

b. areas designated:
   i. by law or by the relevant competent authority for nature protection purposes; or
   ii. for the protection of rare, threatened or endangered ecosystems or species recognised by international agreements or included in lists drawn up by intergovernmental organisations or the International Union for the Conservation of Nature, subject to their recognition in accordance with the second subparagraph of Article 18(4) of the RED;

unless evidence is provided that the production of that raw material did not interfere with those nature protection purposes;

c. highly biodiverse grassland that is:
   i. natural, namely grassland that would remain grassland in the absence of human intervention and which maintains the natural species composition and ecological characteristics and processes; or
   ii. non-natural, namely grassland that would cease to be grassland in the absence of human intervention and which is species-rich and not degraded, unless evidence is provided that the harvesting of the raw material is necessary to preserve its grassland status.

**Directive 2009/28/EC, article 17(3)**

Primary forests (Article 17(3)(a))

According to the RED sustainability certification system primary forests are areas covered with native tree species, do not show clearly visible indications of human activity and the ecological processes are not significantly disturbed.

Clearly visible indications of human activity are:

- Land management (i.e. wood harvest, forest clearance, land use change).
- Heavy fragmentation through infrastructural constructions such as roads and power lines.
- Disturbances of the natural biodiversity (e.g. significant occurrence of non-native plant or animal species).

Undisturbed primary forest are a no-go for biomass extraction.
Nature protection areas according to national law (Article 17(3)(b)(i))
Each country has its own nature protection areas. Examples of protected areas are:

- **National parks**: these areas are identified by national law and are of outstanding importance to the nature conservation of the country. The areas are only slightly altered by human activity. Access to these areas is often restricted.
- **Natural parks**: The areas are important on their geology, climate, habits etc. Most of the areas have unrestricted access, although some of the areas are restricted.
- **Natural areas**: areas protected for their unique wildlife and landscape.
- **Natural reserves**: small enclosures conserving a localised ecosystem, often being wetlands.5

The website [http://protectedplanet.net](http://protectedplanet.net) gives a good indication of the several protected areas throughout Europe. Biomass can be extracted from nature protection areas if evidence is provided that the biomass did not interfere with the nature protection purposes of these areas.

Nature protection areas according to international law (Article 17(3)(b)(ii))
According to the Renewable Energy Directive the recognized nature protection areas as specified in Article 18(4) will be published on the Transparency Platform.6 Up till now (March 2013) the European Commission has not yet recognized any area of this kind.

Highly biodiverse grassland (Article 17(3)(c))
The Renewable Energy Directive article 17(3) indicates that the European Commission shall establish the criteria and geographic ranges to determine which grassland shall be regarded highly biodiverse. A public consultation has been held in 2010 but no final criteria and geographic ranges were published (Jan 2013).

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5 [http://www.andalucia.com/environment/protect/home.htm](http://www.andalucia.com/environment/protect/home.htm)
3.4 Carbon stock

Biofuels and bioliquids shall not be made from raw material obtained from land with high carbon stock, namely land that had one of the following statuses in January 2008 and no longer has that status:

a. wetlands, namely land that is covered with or saturated by water permanently or for a significant part of the year;
b. continuously forested areas, namely land spanning more than one hectare with trees higher than five metres and a canopy cover of more than 30%, or trees able to reach those thresholds in situ;
c. land spanning more than one hectare with trees higher than five metres and a canopy cover of between 10% and 30%, or trees able to reach those thresholds in situ, unless evidence is provided that the carbon stock of the area before and after conversion is such that, when the methodology laid down in part C of Annex V is applied, the conditions laid down in paragraph 2 of this Article would be fulfilled.

The provisions of this paragraph shall not apply if, at the time the raw material was obtained, the land had the same status as it had in January 2008.

Directive 2009/28/EC, article 17(4)

Wetlands (Article 17(4)(a))
According to the RED wetlands are areas covered with or saturated by water permanently or for a significant part of the year. The Ramsar Sites Database (see http://ramsar.wetlands.org/) gives an overview of wetlands designated as internationally important under the Convention on Wetlands. Biomass should not be produced on areas that were still a wetland after 1 January 2008 and no longer have this status. Therefore, biomass can be extracted from wetlands, if the status as wetland is maintained.

Continuously forested areas (Article 17(4)(b))
According to the RED continuously forested areas are areas spanning over one hectare with trees higher than five metres and a canopy cover of more than 30% or trees able to reach those thresholds in situ. Biomass should not be produced on areas that were still continuously forested areas after 1 January 2008 and no longer have this status. If a forest is harvested but is reforested after harvest, the area keeps the status of continuously forested area. In this case biomass harvesting is allowed.

Land with canopy cover of between 10% and 30% (Article 17(4)(b))
According to the RED land is categorised in this category when the area spans over more than one hectare with trees higher than 5 meters and a canopy cover of between 10% and 30%, or trees able to reach these thresholds in situ. These lands can be used for biomass extraction if the land keeps the same status as on 1 January 2008, for instance by replanting of the biomass.
3.5 Former peat land

**Biofuels and bioliquids shall not be made from raw material obtained from land that was peat land in January 2008, unless evidence is provided that the cultivation and harvesting of that raw material does not involve drainage of previously undrained soil.**

*Directive 2009/28/EC, article 17(5)*

Peat is a heterogeneous mixture of more or less decomposed plant (humus) material that has accumulated in a water-saturated environment and in the absence of oxygen (Dehue, Gamba et al. 2011). Peat land is an area with or without vegetation with a naturally accumulated peat layer at the surface. Over 90% of peat lands are in the temperate and cold belt in the Northern Hemisphere. The remaining area is concentrated in tropical and sub-tropical latitudes, much of it under forest.

Figure 1 shows a JRC peat land map of Europe, that can be used as first indication whether former peat land is an issue at all. If the biomass is grown on peat land, evidence needs to be provided that no drainage of previously undrained soil is applied. A verifier will need to check this during the site visit and interviews.

---

8 [http://www.peatsociety.org/peatlands-and-peat](http://www.peatsociety.org/peatlands-and-peat)
Figure 1 Relative cover (%) of peat and peat-topped soils

Source: http://eusoils.jrc.ec.europa.eu/esdb_archive/octop/Peatland.html
3.6 European agricultural legislation

Agricultural raw materials cultivated in the Community and used for the production of biofuels and bioliquids shall be obtained in accordance with the requirements and standards under the provisions referred to under the heading ‘Environment’ in part A and in point 9 of Annex II to Council Regulation (EC) No 73/2009 of 19 January 2009 establishing common rules for direct support schemes for farmers under the common agricultural policy and establishing certain support schemes for farmers and in accordance with the minimum requirements for good agricultural and environmental condition defined pursuant to Article 6(1) of that Regulation.

Directive 2009/28/EC, article 17(6)

This sustainability criterion from the Renewable Energy Directive is not applicable to pyrolysis oil made of woody biomass.

3.7 Conclusion

The sustainability criteria of the Renewable Energy Directive have been assessed in detail. The information in this chapter can be used by pyrolysis oil producers and biomass producers to check whether their biomass production meets the requirements of the RED. Such a self assessment has no official status, but is a good preparation for official certification by a third party. Also, it is good to keep these requirements in mind when sourcing biomass.
4 PYROLYSIS OIL CERTIFICATION

4.1 EU recognised biomass sustainability certification systems

At present (April 2013) thirteen voluntary certification systems have been recognised by the European Commission for compliance to the sustainability requirements in the RED\(^\text{10}\). This recognition applies directly in 27 EU Member States.

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full name</th>
<th>Feedstocks</th>
<th>Geographic locations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ISCC</td>
<td>International Sustainability and Carbon Certification</td>
<td>All</td>
</tr>
<tr>
<td>2</td>
<td>Bonsucro</td>
<td>Bonsucro EU</td>
<td>Sugar cane (for the production of bioethanol)</td>
</tr>
<tr>
<td>3</td>
<td>RTRS EU RED</td>
<td>Round Table on Responsible Soy EU RED</td>
<td>Soy</td>
</tr>
<tr>
<td>4</td>
<td>RSB EU RED</td>
<td>Roundtable of Sustainable Biofuels EU RED</td>
<td>All</td>
</tr>
<tr>
<td>5</td>
<td>2BSvs</td>
<td>Biomass Biofuels voluntary scheme</td>
<td>All</td>
</tr>
<tr>
<td>6</td>
<td>RBSA</td>
<td>Abengoa RED Bioenergy Sustainability Assurance</td>
<td>All</td>
</tr>
<tr>
<td>7</td>
<td>Greenergy</td>
<td>Greenergy Brazilian Bioethanol verification programme</td>
<td>Sugar cane (for the production of bioethanol)</td>
</tr>
<tr>
<td>8</td>
<td>Ensus</td>
<td>Ensus voluntary scheme under RED for Ensus bioethanol production</td>
<td>Wheat (for the production of bioethanol)</td>
</tr>
<tr>
<td>9</td>
<td>Red Tractor</td>
<td>Red Tractor Farm Assurance Combinable Crops &amp; Sugar Beet Scheme</td>
<td>cereals, oilseeds, sugar beet</td>
</tr>
<tr>
<td>10</td>
<td>SQC</td>
<td>Scottish Quality Farm Assured Combinable Crops (SQC) scheme</td>
<td>Winter wheat, maize, oil seed rape</td>
</tr>
<tr>
<td>11</td>
<td>Red Cert</td>
<td>Renewable Energy Directive Certification system</td>
<td>Biomass defined in Annex V of the RED EU and selected third countries</td>
</tr>
<tr>
<td>12</td>
<td>NTA 8080</td>
<td>NTA 8080</td>
<td>All</td>
</tr>
<tr>
<td>13</td>
<td>RSPO RED</td>
<td>Roundtable on Sustainable Palm Oil RED</td>
<td>Palm oil</td>
</tr>
</tbody>
</table>

\(^{10}\) [http://ec.europa.eu/energy/renewables/biofuels/sustainability_schemes_en.htm](http://ec.europa.eu/energy/renewables/biofuels/sustainability_schemes_en.htm)
Table 1 shows that five certification systems (ISCC, RSB EU RED, 2Bsvs, RBSA, NTA8080) are applicable to all biomass feedstock and all geographic locations, and therefore potentially applicable to pyrolysis oil production. However, with the exception of NTA 8080 their main focus is directed to the certification of agricultural biomass for bioethanol and biodiesel production. All five systems are summarised in the next sections.

**Traditional forest certification schemes**

Forest certification systems like FSC and PEFC do not include a greenhouse gas savings calculation. As a consequence, FSC and PEFC certification alone is not sufficient to meet the sustainability requirement of the RED. No indications were found that these forest certification systems will apply for (partial) EU RED recognition. The main market for forest certification systems is the certification for non-energy purposes and there is no large production of liquid biofuels made from wood yet. Nevertheless FSC and PEFC certification is an advantage, as many sustainability requirements are already met and the origin of the biomass has already been tracked, so the “chain-of-custody” can easily be verified.

### 4.2 Description of relevant biomass certification systems

#### 4.2.1 ISCC

The International Sustainability and Carbon Certification System (ISCC) is governed by the ISCC association. The ISCC system was financially supported by the BMELV, the German Ministry of Food, Agriculture and Consumer Protection, through FNR. The sustainability requirements exceed the RED requirements and include:

- **Principle 1**: Biomass shall not be produced on land with high biodiversity value or high carbon stock and not from peat land (according to Article 17, 3, of the RED and § 4 to 6 of the German BioSt-NachV and BioKraft-NachV). HCV areas shall be protected.
- **Principle 2**: Biomass shall be produced in an environmentally responsible way. This includes the protection of soil, water and air and the application of Good Agricultural Practices.
- **Principle 3**: Safe working conditions through training and education, use of protective clothing and proper and timely assistance in the event of accidents.
- **Principle 4**: Biomass production shall not violate human rights, labour rights or land rights. It shall promote responsible labour conditions and workers’ health, safety and welfare and shall be based on responsible community relations.

The ISCC website shows more than 1100 valid certificates. ISCC is a truly international certification systems with certificate holders in many countries like Czech Republic, Germany, France, USA, UK, the Netherlands, Indonesia, etc. Seventeen certification bodies can perform ISCC certification. Operators that would like to use the ISCC system have to pay a registration fee (50-500 Euro once), a certificate fee (50-500 Euro/certificate) and a charge fee of 0.02-0.03 Euro per tonne of sustainable liquid or biofuel.
Its popularity in many countries shows that the system works well in practise. All documentation can be found on http://www.iscc-system.org/.

Although ISCC has formal EC approval to certify all biomass sources, it appears that in the category of woody biomass sources, only short rotation coppice can be certified right away\(^\text{11}\). Certification of other wood sources requires the formulation of further guidance to verification bodies. ISCC has a positive attitude towards pyrolysis oil certification and is willing to work on this guidance in cooperation with parties interested in ISCC certification.

4.2.2 RSB EU RED

The Roundtable on Sustainable Biofuels (RSB) is an international initiative co-ordinated by the Energy Center at the Swiss Federal Institute of Technology in Lausanne. Already in 2007 the steering Board of the RSB published draft principles for sustainable biofuels production that since then have been through various rounds of stakeholder consultation with a significant share of NGO participation. The RSB EU RED exceeds the requirements in the RED directive and includes:

- Principle 1: Legality (national and international laws and regulation)
- Principle 2: Planning, monitoring and continuous improvement (transparent and consultative impact assessment, and economic viability)
- Principle 3: Greenhouse gas emissions (Biofuel blend must be 50% better over lifecycle than fossil fuel)
- Principle 4: Human and labour rights (protect workers’ and human rights)
- Principle 5: Rural and social development (focus regions of poverty)
- Principle 6: Local food security (direct impacts)
- Principle 7: Conservation (conserve and protect important conservation values, ecosystem services and functions)
- Principle 8: Conserve and protect soil
- Principle 9: Conserve and protect water
- Principle 10: Conserve and protect air
- Principle 11: Use of technology, inputs, management of waste (risks, chemicals, wastes)
- Principle 12: Land rights (respect land rights and land use rights).

The principles and whole certification system are well documented. The RSB has been slower in implementation than some of the other systems. The RSB website shows that only a handful certificates have been issued and that four certification bodies have been approved (March 2013). No overview of fees could be found. The certification scheme is complete and very well documented, but not much experience has been gained yet with the use of the scheme in practice. RSB has confirmed that bioliquids can be certified with the current RSB standard\(^\text{12}\).

\(^{11}\) Vis, M. (2013) Personal communication with Mr. Feige (ISCC), 17 Jan 2013
\(^{12}\) Vis, M. (2013) Email correspondence with Mr. Haye (RSB), 14 March 2013
4.2.3 2BSvs

The 2BS consortium was founded in 2010 by the French biofuel, biodiesel and bioethanol production industries to create and manage the 2BSvs Biomass Biofuels Sustainability voluntary scheme, helping to comply to the European Union requirements in terms of biofuel sustainability. The French 2BSvs follows quite literally the requirements of the RED. It makes a distinction between obligatory criteria that shall be followed and other sustainability issues mentioned in the RED that are currently not obligatory for economic operators that should be followed. The latter category of sustainability issues includes (1) agro-environmental practices; (2) soil, water and air protection and (3) social sustainability as described in the RED. The sustainability criteria do not go beyond the RED. The scheme is open to all economic operators. The criteria related to the production of biomass on highly biodiverse grassland was not approved by the European Commission. Seven verification bodies can perform certification by 2BSvs and a large number of more than 500 mainly French economic operators have been certified. Also a limited number of German, Italian, Belgian, and Australian economic operators were found. The fees are 500 Euro/year for first gathering point, 500-4,000 Euro/year for processing economic operators and 3,000 Euro/year for traders and export operators. More information can be found on http://en.2bsvs.org/. This certification system could potentially be used for pyrolysis oil certification, but initial inquiry did not lead to any further communication, so their interest in pyrolysis oil certification might be low.

4.2.4 RBSA

Abengoa Bioenergia is a producer of biofuels with production facilities in Europe, the USA and Brazil. The company has developed the “RED Bioenergy Sustainability Assurance Scheme” (RBSA), initially intended for use by the company’s own biofuel production and retail operations, but also by any economic operators interested in joining the programme. The sustainability criteria meet the EU RED requirements but do not list any additional sustainability requirements. The documentation of the RBSA certification was not found on the website of Abengoa, which leaves the impression that providing certification services to other economic operators has not the company’s priority. Therefore, this system seems not useful for certification of pyrolysis oil.

4.2.5 NTA8080

NTA8080 is based on the Dutch Cramer Criteria, one of the first complete sets of sustainability criteria for biomass. The NTA8080 version 2009 is not available for free but can be ordered at the web shop of the Dutch standards organisation NEN. Although the documents are affordable, this might be an initial barrier to potentially interested economic operators. Other certification systems offer their documentation for free. In combination with the NTA 8081 that describes the certification scheme, and the interpretation document 07 linked to NTA8081 (both available for free on http://www.duurzame-biomassa.org), a complete EU approved certification system is in place. The sustainability criteria exceed the requirements of the RED, also related to greenhouse gas emission savings (50% after 2012 instead of 35% as required in the RED). The principles are listed below:
• Principle 1: The greenhouse gas balance of the production chain and application of the biomass is positive.
• Principle 2: Biomass production is not at the expense of important carbon sinks in the vegetation and in the soil.
• Principle 3: The production of biomass for energy shall not endanger the food supply and local biomass applications (energy supply, medicines, building materials).
• Principle 4: Biomass production does not affect protected or vulnerable biodiversity and will, where possible, strengthen biodiversity.
• Principle 5: In the production and conversion of biomass, the soil and soil quality are retained or even improved.
• Principle 6: In the production and conversion of biomass, ground and surface water are not depleted and the water quality is maintained or improved.
• Principle 7: In the production and conversion of biomass, the air quality is maintained or improved.
• Principle 8: The production of biomass contributes towards local prosperity.
• Principle 9: The production of biomass contributes towards the social well-being of the employees and the local population.

According to the NTA 8080 website three certification bodies can submit NTA8080 certification. So far more than 25 certificates have been submitted, for green gas, biodiesel, ethanol and three for woody biomass. Although the total number of certificates is still modest, the fact that also woody biomass has been certified makes NTA8080 interesting for pyrolysis oil. The standard holder NEN and two certification bodies have confirmed that NTA8080 certification of pyrolysis oil is possible.

4.3 Summary and selection of certification systems

The main characteristics of the relevant certification systems are summarised in Table 2. The German ISCC and French 2BSvs have issued the most certificates and are fully operational. The RSB EU RED system has still not been applied much in practice. NTA8080 has received EC approval in August 2012. The status of Abengoa’s RBSA system is unknown and no dedicated website for this certification system was found, giving the impression that attracting other economic partners to utilise the RBSA has not a high priority.
Table 2. Evaluation applicability of EC recognised biomass certification systems

<table>
<thead>
<tr>
<th>Evaluation topics</th>
<th>ISCC</th>
<th>RSB EU RED</th>
<th>2BSvs</th>
<th>RBSA</th>
<th>NTA8080</th>
</tr>
</thead>
<tbody>
<tr>
<td>System is fully operational (more than &gt;100 certificates)</td>
<td>yes</td>
<td>start-up</td>
<td>yes</td>
<td>unknown</td>
<td>start-up</td>
</tr>
<tr>
<td>Certification system available for all economic operators</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>unknown</td>
<td>Yes</td>
</tr>
<tr>
<td>All documentation available on internet</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>No</td>
<td>yes</td>
</tr>
<tr>
<td>Calculation of actual value GHG emission savings possible?</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>Yes</td>
<td>yes</td>
</tr>
<tr>
<td>Covering more than RED criteria</td>
<td>+</td>
<td>++</td>
<td>+/-</td>
<td>-</td>
<td>++</td>
</tr>
<tr>
<td>Certification of wood based pyrolysis oil in possible</td>
<td>partially</td>
<td>yes</td>
<td>unknown</td>
<td>unknown</td>
<td>yes</td>
</tr>
<tr>
<td>Certificates found of woody biomass or bioliquids</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>unknown</td>
<td>yes</td>
</tr>
</tbody>
</table>

a) Unlike the other schemes, key documents are not available for free
b) No documentation or explanation on how economic operators could use the RBSA scheme was found on internet.
c) The actual value GHG emission calculation method is necessary for pyrolysis oil certification. Some certification schemes only work with default values, which are not available for pyrolysis oil production.
d) ISCC has the procedures for certification of short rotation coppice ready. Certification of other woody biomass requires the development of procedures for verifiers, based on the experience of wood owners and traders.

Three certification systems cover more sustainability topics than required according to the EU RED: ISCC, RSB EU RED and NTA8080. A comparison of the most relevant topics are summarised in Table 3. The comparison of certification systems is elaborated on in more detail in Annex B, based on the work of (van Dam, 2010).

Table 3. Overall appreciation of the coverage of sustainability topics beyond RED requirements in NTA8080, RSB EU RED and ISCC

<table>
<thead>
<tr>
<th>Sustainability topics covered</th>
<th>NTA8080</th>
<th>RSB EU RED</th>
<th>ISCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biodiversity</td>
<td>++</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>Soil quality and quantity</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Water quality and quantity</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Other environmental topics</td>
<td>++</td>
<td>++</td>
<td>+/-</td>
</tr>
<tr>
<td>Social well-being workers</td>
<td>+</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>Well-being local communities</td>
<td>++</td>
<td>++</td>
<td>+</td>
</tr>
</tbody>
</table>
Conclusion
Of the thirteen EC approved voluntary biomass sustainability schemes, only three schemes can be used for EU RED certification of bioliquids like pyrolysis oil: ISCC, RSB EU RED and NTA8080.

As shown in Table 2 and Table 3 these three schemes have their own characteristics that should be taken into consideration when selecting a scheme for bioliquids certification:

- ISCC is the scheme with the highest operational experience. ISCC has the procedures for certification of bioliquids from short rotation coppice. Certification of other woody biomass is not readily available; it requires the development of procedures for verifiers, that will start up depending on the market needs.
- RSB EU RED has the most stringent sustainability requirements that have been developed in a proper and transparent way. RSB can be regarded as the most “green” scheme. Practical experience with the operation of the scheme is however still limited.
- NTA8080 also covers the sustainability topics more exhaustively than ISCC. It has more operational experience than RSB but less than ISCC. The NTA8080 has historically the broadest scope, NTA8080 certificates have been submitted for solid, liquid and gaseous biomass. This broad scope makes the scheme very suitable for certification of bioliquids made of woody and other solid biomass.
REFERENCES


A. EVALUATION OF SUSTAINABILITY TOPICS IN NTA8080, RSB, EU RED AND ISCC

Y = included as a principle;
y = mentioned explicitly in criteria or included as separate criterion.

Table 4 Biodiversity topics included in the certification schemes. Based on (van Dam 2010)

<table>
<thead>
<tr>
<th>Topic</th>
<th>NTA8080</th>
<th>RSB EU RED</th>
<th>ISCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary forests specifically mentioned</td>
<td>-</td>
<td>-</td>
<td>Y</td>
</tr>
<tr>
<td>Biodiverse grassland specifically mentioned</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>New plantings specifically mentioned</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Nature prot. areas by relevant authority (nat. level)</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Protected areas recognised by international agreements (Ramsar, Kyoto, CBD)</td>
<td>Y</td>
<td>Y</td>
<td>-</td>
</tr>
<tr>
<td>Protected areas in lists drawn up by IUCN</td>
<td>Y</td>
<td>Y</td>
<td>-</td>
</tr>
<tr>
<td>Protected areas defined by stakeholder process</td>
<td>-</td>
<td>Y</td>
<td>-</td>
</tr>
<tr>
<td>Additional criteria</td>
<td>Y</td>
<td>Y</td>
<td>-</td>
</tr>
<tr>
<td>Appreciation</td>
<td>++</td>
<td>++</td>
<td>+</td>
</tr>
</tbody>
</table>

Table 5 Identified criteria and indicators for soil quality and quantity included in the certification schemes. Based on (van Dam 2010)

<table>
<thead>
<tr>
<th>Topic</th>
<th>NTA8080</th>
<th>RSB EU RED</th>
<th>ISCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Records of fertilizer/agrochemical inputs</td>
<td>-</td>
<td>Y</td>
<td>-</td>
</tr>
<tr>
<td>Records and monitoring (incl. analysis, translation to management plans)</td>
<td>Y</td>
<td>Y</td>
<td>-</td>
</tr>
<tr>
<td>Identification of soil types on each site of area</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Maps of (fragile) soils are available</td>
<td>-</td>
<td>Y</td>
<td>-</td>
</tr>
<tr>
<td>Compliance of relevant laws and regulations</td>
<td>Y</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Indicated parameters for analysis soil quality</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soil organic carbon</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Soil organic matter</td>
<td>Y</td>
<td>Y</td>
<td>-</td>
</tr>
<tr>
<td>pH soil</td>
<td>Y</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Nitrogen, phosphor and potassium</td>
<td>Y</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Quality surface residues</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Soil suitability for intended crops</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Soil salts content</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Indicated parameters for analysis soil quantity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soil loss in tons/ha/year</td>
<td>Y</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Quantity and use of surface residues</td>
<td>Y</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Info on susceptibility soil to erosion</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Info on conformation, slope, land form</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Info on wind exposure soil</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Field observations on evidence (or not) from erosion or evidence of practices</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Plans and strategies mentioned</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Soil management plan or strategy</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Topic</td>
<td>NTA8080</td>
<td>RSB EU RED</td>
<td>ISCC</td>
</tr>
<tr>
<td>--------------------------------------------------</td>
<td>---------</td>
<td>------------</td>
<td>------</td>
</tr>
<tr>
<td>Monitoring of water used for irrigation</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Records and monitoring (incl. analysis, translation to management plans)</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Compliance with relevant laws and regulations</td>
<td>Y</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Address effects of water use on local resources</td>
<td>-</td>
<td>-</td>
<td>Y</td>
</tr>
<tr>
<td>Indicated parameters for analysis water quality</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Dissolved oxygen</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>-</td>
<td>-</td>
<td>Y</td>
</tr>
<tr>
<td>Phosphor</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Turbidity</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>BOD level on/near production unit</td>
<td>Y</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total suspended solids in mg/l</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Agrochemical inputs in input/ha/year</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Origin of (irrigation) water</td>
<td>Y</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Indicated parameters for analysis water quantity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net water consumed per unit mass of product</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mill water use per ton of FFB</td>
<td>Y</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Use of (irrigation) water sources in l/ha/yr</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Data records for irrigation prediction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plans and strategies mentioned</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water management plan</td>
<td>-</td>
<td>Y</td>
<td>-</td>
</tr>
<tr>
<td>Plan or documentation indicating best practices</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Plan for minimising subsidence of peat soils</td>
<td>-</td>
<td>Y</td>
<td>-</td>
</tr>
<tr>
<td>Appreciation</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

\(a\) Remark from the author: ash recycling is mentioned in NTA8080.

Table 6 Identified criteria and indicators for water quality and quantity included in the certification schemes. Based on (van Dam 2010)
Table 7 Identification of variety of environmental topics included in the certification schemes. Based on (van Dam 2010)

<table>
<thead>
<tr>
<th>Topic</th>
<th>NTA8080</th>
<th>RSB EU RED</th>
<th>ISCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good (farming) practices</td>
<td>y</td>
<td>Y</td>
<td>-</td>
</tr>
<tr>
<td>Waste</td>
<td>y</td>
<td>y</td>
<td>-</td>
</tr>
<tr>
<td>Air</td>
<td>Y</td>
<td>Y</td>
<td>-</td>
</tr>
<tr>
<td>Fire</td>
<td>y</td>
<td>y</td>
<td>-</td>
</tr>
<tr>
<td>GMO</td>
<td>-</td>
<td>y</td>
<td>-</td>
</tr>
<tr>
<td>Pesticide management</td>
<td>y</td>
<td>y</td>
<td>Y</td>
</tr>
<tr>
<td>No invasive species</td>
<td>-</td>
<td>y</td>
<td>-</td>
</tr>
<tr>
<td>Hygiene, quality product</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Appreciation</td>
<td>++</td>
<td>++</td>
<td>+/-</td>
</tr>
</tbody>
</table>

Table 8 Overview of selected principles on social well-being of workers included in the certification schemes. Based on (van Dam 2010)

<table>
<thead>
<tr>
<th>Topic</th>
<th>NTA8080</th>
<th>RSB EU RED</th>
<th>ISCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>No child labour</td>
<td>Y(^a)</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Minimum age (years)</td>
<td>-</td>
<td>Y</td>
<td>-</td>
</tr>
<tr>
<td>Freedom from discrimination</td>
<td>Y(^a)</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Freedom of labour; no forced labour</td>
<td>Y(^a)</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Freedom of association and collective bargaining; freedom to organise and negotiate</td>
<td>Y(^a)</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Right of indigenous people explicitly mentioned</td>
<td>Y(^a)</td>
<td>Y</td>
<td>-</td>
</tr>
<tr>
<td>Appreciation</td>
<td>+</td>
<td>++</td>
<td>+</td>
</tr>
</tbody>
</table>

\(^a\) NTA8080 refers directly to the UN ‘Universal Declaration of Human Rights’.
Table 9 Overview of selected principles on well-being of local communities included in the certification schemes. Based on (van Dam 2010)

<table>
<thead>
<tr>
<th>Topic</th>
<th>NTA8080</th>
<th>RSB EU RED</th>
<th>ISCC</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Legal and customary rights</strong></td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td><strong>Procedures</strong></td>
<td>y</td>
<td>y</td>
<td>-</td>
</tr>
<tr>
<td><strong>Proof of ownership</strong></td>
<td>y</td>
<td>y</td>
<td>y</td>
</tr>
<tr>
<td><strong>Compensation systems available</strong></td>
<td>y</td>
<td>y</td>
<td>-</td>
</tr>
<tr>
<td><strong>Well-being local communities</strong></td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td><strong>Contribution towards local economy and activities</strong></td>
<td>y</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Fair and transparent prices available</strong></td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Compensation for use traditional knowledge</strong></td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Preference employment of local people</strong></td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Local procurement services and inputs</strong></td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Support local education</strong></td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Safeguarding local food security</strong></td>
<td>-</td>
<td>y</td>
<td>y</td>
</tr>
<tr>
<td><strong>No replacement of staple crops</strong></td>
<td>-</td>
<td>y</td>
<td>y</td>
</tr>
<tr>
<td><strong>Use of (co-) products does not affect traditional/local use</strong></td>
<td>y</td>
<td>y</td>
<td>-</td>
</tr>
<tr>
<td><strong>Participation/communication local people</strong></td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td><strong>Procedures or methods established</strong></td>
<td>y</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Complaints and grieving mechanism</strong></td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Social Impact Assessment in participatory way</strong></td>
<td>Y</td>
<td>Y</td>
<td>-</td>
</tr>
<tr>
<td><strong>Existence of social management plan</strong></td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Specific measures to target vulnerable groups</strong></td>
<td>-</td>
<td>y</td>
<td>-</td>
</tr>
<tr>
<td><strong>Take measures to counteract negative effects</strong></td>
<td>y</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Mentioned parameters for SIA are:</strong></td>
<td>Y</td>
<td>Y</td>
<td>-</td>
</tr>
<tr>
<td><strong>Access and use rights/land tenure</strong></td>
<td>y</td>
<td>y</td>
<td>-</td>
</tr>
<tr>
<td><strong>Physical and economic displacement</strong></td>
<td>y</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Economic livelihoods, working conditions</strong></td>
<td>-</td>
<td>y</td>
<td>-</td>
</tr>
<tr>
<td><strong>Job creation and potential loss</strong></td>
<td>-</td>
<td>y</td>
<td>-</td>
</tr>
<tr>
<td><strong>Subsistence activities</strong></td>
<td>-</td>
<td>y</td>
<td>-</td>
</tr>
<tr>
<td><strong>Cultural and religious values</strong></td>
<td>y</td>
<td>y</td>
<td>-</td>
</tr>
<tr>
<td><strong>Gender differences</strong></td>
<td>y</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Health and education facilities</strong></td>
<td>Y</td>
<td>Y</td>
<td>-</td>
</tr>
<tr>
<td><strong>Other community values</strong></td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Appreciation</strong></td>
<td>++</td>
<td>++</td>
<td>+</td>
</tr>
</tbody>
</table>

Table 10 Overall appreciation of the coverage of sustainability topics in NTA8080, RSB EU RED and ISCC

<table>
<thead>
<tr>
<th>Sustainability topics covered</th>
<th>NTA8080</th>
<th>RSB EU RED</th>
<th>ISCC</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Biodiversity</strong></td>
<td>++</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td><strong>Soil quality and quantity</strong></td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td><strong>Water quality and quantity</strong></td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td><strong>Other environmental topics</strong></td>
<td>++</td>
<td>++</td>
<td>+/-</td>
</tr>
<tr>
<td><strong>Social well-being workers</strong></td>
<td>+</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td><strong>Well-being local communities</strong></td>
<td>++</td>
<td>++</td>
<td>+</td>
</tr>
</tbody>
</table>