Renewable and Sustainable Energy Reviews 138 (2021) 110645

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: http://www.elsevier.com/locate/rser

Effective sustainability criteria for bioenergy: Towards the implementation of the european renewable directive II

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ARTICLE INFO

Keywords:
bioenergy
Biofuels
Heat and electricity
Certification
Sustainability criteria
RED II
Sustainability requirement
National legislation
Voluntary scheme

ABSTRACT

Sustainability criteria and verification through national legislations and voluntary certification schemes are important tools to ensure sustainable supply and bioenergy development in the European Union. The Renewable Energy Directive Recast (RED II) sets the framework for renewable energy support for the period 2021–2030 with updated and new sustainability criteria. This study reviews the sustainability criteria in the RED II and in existing national legislations and voluntary schemes. The aim is to identify possible gaps and good practices in certification to propose a set of sustainability criteria that are effective in their coverage of the most urgent sustainability concerns, and that are practically applicable to the whole bioenergy sector. The proposed set of effective sustainability criteria was validated through stakeholder interviews. The results show that the RED II is a major step forward in safeguarding sustainable bioenergy supply; however, it still entails sustainability risks in forest management and lacks clarifications and criteria for imported biomass feedstocks. The proposed effective sustainability criteria in this study are more extensive than in the RED II and help to assure sustainable land use, to protect biodiversity, and to conserve ecosystems, whilst also addressing rights for workers and local communities, and the efficient use of resources. These criteria are already implemented in some comprehensive and stringent national support schemes and voluntary schemes. It is recommended that policy makers, scheme owners and sustainability practitioners coordinate discussions and agreements on the various sustainability aspects. A clear definition of waste and residues, measurement of indirect land use change, and recognition of competent voluntary schemes to demonstrate sustainability compliance should be considered at EU level.

1. Introduction

1.1. Bioenergy development in the European Union

Renewable energy, including bioenergy, plays an important role in the European Union (EU) in improving energy supply security by reducing dependence of the EU on (imported) fossil fuels, making energy supply more sustainable, and mitigating climate change [1–4]. Since 2001, renewable energy policies have stimulated the rapid development of bioenergy in the EU. Gross inland consumption of bioenergy increased from 2320 PJ in 2000 to 5880 PJ in 2017 [5]. Today, bioenergy accounts for 64% of gross inland consumption of renewable energy, and it is expected to remain the largest source of renewable energy for the coming decade [5].

The development of bioenergy in the past decade was shaped largely by the targets set in the Renewable Energy Directive 2009/28/EC (RED I). The RED I established binding specific national targets for renewable energy to be met by 2020: a contribution of 20% to the total final energy supply in the EU, and of at least 10% to the transport sector in each Member State (MS). In 2018, the revised Renewable Energy Directive Recast (RED II) was adopted [6], succeeding the RED I in promoting the use of renewable energy in the EU for the period 2021–2030. It sets a new binding renewable energy target for 2030 of at least 32% of the gross final energy consumption and a sub-target of renewable energy supply in transport of at least 14%. To meet these targets, bioenergy consumption is projected to increase to 8.0 EJ by 2030. Scenarios aimed at meeting the climate target as agreed in the Paris Climate Agreement show that beyond 2030, bioenergy will still contribute significantly to the renewable energy supply, ranging between 8.0 and 10.5 EJ by 2050 [4]. In the Paris Climate Agreement, the EU committed to reducing the greenhouse gas (i) emissions and to limiting the increase in temperature

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https://doi.org/10.1016/j.rser.2020.110645
Received 4 January 2020; Received in revised form 31 October 2020; Accepted 29 November 2020
Available online 18 December 2020

List of abbreviations including units and nomenclature

BSvs	Biomass Biofuels voluntary scheme
CAP	Common Agricultural Policy
CoC	Chain of Custody
EC	European Commission
EU	European Union
FMU	Forest Management Unit
FSC	Forest Stewardship Council
GC	Belgian Green Certificates
GHG	Greenhouse Gas emissions
GTAS	Gafta Trade Assurance Scheme
HVO	HVO Verification Scheme
(I)LUC	(Indirect) Land Use Change
ISCC	International Sustainability and Carbon Certification
KZR	KZR INIG System
LIIB	The Low Indirect Impact Biofuels
LULUCF	Land Use, Land Use Change and Forestry
NGO	Non-Governmental Organisation
MS	Member State
PEFC	Programme for the Endorsement of Forest Certification
RBA	Risk Based Approach
RED	Renewable Energy Directive
Red Tractor	Red Tractor Farm Assurance Combinable Crops & Sugar Beet Scheme
RO	The United Kingdom Renewable Obligation Order
RSB	Roundtable on Sustainable Biomaterials
RSBO	Roundtable on Sustainable Palm Oil
RTFO	United Kingdom Renewable Transport Fuel Obligation Order
RTRS	Round Table on Responsible Soy
SBP	Sustainable Biomass Program
SDE+	Dutch Stimulation of Sustainable Energy Production
SFM	Sustainable Forest Management
SQC	Scottish Quality Farm Assured Combinable Crops
Trade Assurance	Trade Assurance Scheme for Combinable Crops
UFAS	Universal Feed Assurance Scheme
UK	United Kingdom
WTO	World Trade Organisation

to well below 2° Celsius. The increased consumption of bioenergy will enhance efforts of the EU to move towards a low carbon economy by 2050 [4].

1.2. European sustainability framework for bioenergy and pending issues

1.2.1. Early development of bioenergy policies to guarantee sustainability

Along the development of bioenergy in the past few decades, the growth of liquid biofuels produced from food-based crops has led to concerns over possible impacts on agricultural food production and land use change [7]. In response to these impacts, biofuels used in transport and bioliquids used in electricity, heating and cooling must comply with EU-wide binding sustainability criteria [8]. Sustainability compliance of biofuels and bioliquids needs to be verified either through national legislations or through voluntary schemes that are recognised by the European Commission (EC). The sustainability criteria are part of a larger sustainability framework, partly also regulated in the EU through the environmental cross-compliance requirements in the Common Agricultural Policy (CAP) and in the national forest management programme guided by the EU Forestry Strategy [9]. As a result of the RED I implementation, the volume of certified transport biofuels in the EU has increased to nearly 100% (see Fig. 1).

The RED I did not define sustainability criteria for solid and gaseous biomass in electricity, heating, and cooling. In the 2010 report of the EC to the European Parliament and the Council, sustainability risks were considered low for the solid and gaseous biomass in electricity, heating, and cooling a [9]. Domestic biomass that originates from waste and residues, agricultural, and forestry residues was deemed unlikely to trigger direct or indirect land use change ((i)LUC). However, to further respond to sustainability concerns and avoid negative sustainability impacts, the EC encouraged its MSs to develop national sustainability criteria for solid biomass, addressing land use, land use change, and forestry (LULUCF) and minimum GHG emissions savings [9,10]. Some flexibility was given to MSs as it was difficult to establish EU-wide sustainability criteria for solid biomass: different feedstocks are used in different MSs, which presents challenges for consistent sustainability

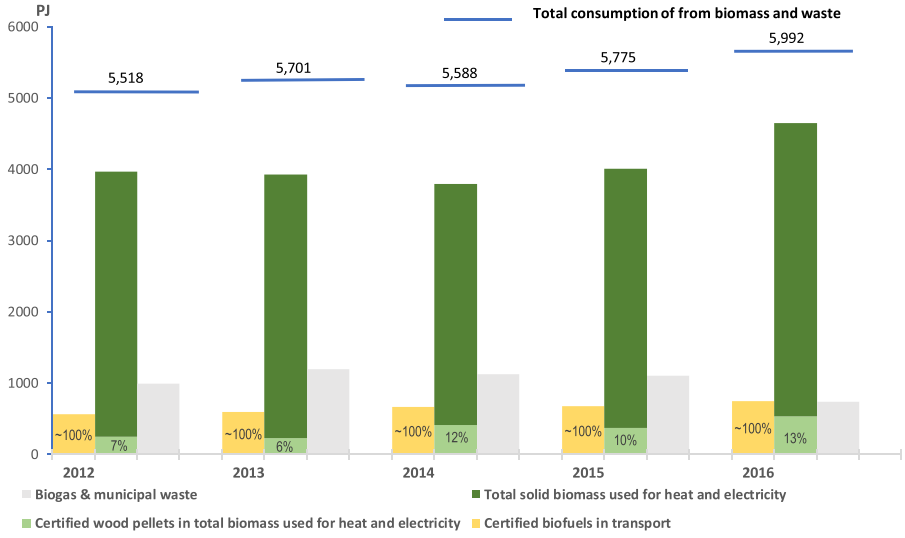

Fig. 1. Sustainably certified biofuels in transport and the share of sustainably certified solid biomass in total solid biomass used for heat and electricity in the EU. The amount of certified biogas is unknown. Municipal solid waste is not required to be certified. Based on sources [11–13]:

compliance. MSs were advised to translate sustainability criteria into their own legislation, following the criteria applying to biofuels and bioliquids [9].

1.2.2. EU binding sustainability criteria for all bioenergy sectors

International biomass trade of both liquid biofuels and solid biomass has grown substantially in the past two decades [14]. The main importing countries, including the United Kingdom (UK), Belgium, the Netherlands, and Denmark have adopted sustainability criteria for solid biomass at the national level. These sustainability criteria were established to ensure GHG emission savings whilst assuring that solid biomass is produced in a sustainable way, and sustainability impacts in the sourcing countries outside the EU are avoided [15,16]. With the implementation of these national criteria, the volume of certified solid biomass has increased gradually in the whole EU, from 3% in 2012 to 10% of total solid biomass used for heat and electricity in 2016 (see also Fig. 1). However, some concerns still exist. On the one hand, it has been shown that not all types of biomass are instantaneously carbon-neutral [17]; moreover, risks of negative impacts of biomass to biodiversity, soil, water, and land use remain [18–20]. On the other hand, it creates an administrative burden to prove comprehensive sustainability compliance with divergent national regulations and initiatives. Proof of compliance to these divergent systems has been shown to be a barrier to international and intra-EU trade in solid biomass fuels, thus making it more difficult or costly to meet increasing biomass demand [21].

In 2018 the RED II was adopted, aiming to minimise these concerns, to avoid environmental impacts and market distortions, to promote resource efficiency, and to safeguard both proportionality and cost-effectiveness (by applying risk-based approach and thresholds for bio-heat and power plants). The RED II establishes binding environmental criteria for large plants (with a total rated thermal input equal to or exceeding 2 MW for gaseous biomass fuels and 20 MW for solid biomass fuels). In fact, the RED II allows MSs to establish stricter and/or additional sustainability criteria for solid biomass. The transposition to the national level needs to be completed by the end of 2020.

Studies assessing sustainability criteria defined in the proposed RED II [22] (which are almost identical in the final version of the RED II) found weak and uncomprehensive definitions of some sustainability criteria regarding sustainable forest management (SFM), waste and residues, and ILUC. Some of these studies showed the risk of unsustainable mobilisation of feedstocks for bioenergy production [23,24]: as long as legality of harvesting operations and forest regeneration are proven, bioenergy can in principle be produced from biomass harvested in primary forests or in high-biodiversity non-primary forests. This has already been disapproved of by environmental non-governmental-organisations (NGOs), amongst others due to the risk of depleting carbon stocks [19]. One study identified that although oil palm will be gradually phased out to be used for bioenergy production, it criticized that palm oil residues – e.g. empty palm fruit bunches – can still be used [25]. Also biofuels, bioliquids and biomass fuels may only be certified as low ILUC fuels if they are applied by small holders, which bear some loopholes to ILUC prevention [25].

Given the context of additional and new sustainability criteria applied for the whole bioenergy sector and unsolved sustainability concerns of bioenergy challenges of transposing and implementing sustainability criteria in MSs remain. The updated and new sustainability criteria defined in RED II may add more complexity for policy makers, voluntary scheme owners, certification bodies and auditors involved in sustainability certification. Furthermore, different sustainability criteria have been implemented separately in many voluntary schemes and national legislations [26–28]; therefore, selecting relevant sustainability criteria is burdensome. Nevertheless, there may be lessons for stakeholders to learn from the establishment and verification of sustainability criteria in those systems for the promotion of sustainable bioenergy at the MS level.

1.3. Objectives

This study aims to address pending sustainability issues of the RED II and proposes efficient sustainability criteria to assure sustainability compliance for the all bioenergy sectors. It also aims to identify good practices in certification for interested stakeholders to certify sustainable bioenergy in practice. In detail, the study:

- reviews sustainability criteria defined in RED II and identifies possible gaps in sustainability compliance
- reviews sustainability criteria established in voluntary schemes and national legislations for biofuels and solid biomass, and investigates to what extent they meet the RED II's sustainability criteria
- proposes effective sustainability criteria that respond to sustainability concerns and that can actually be implemented in practice
- provides recommendations based on good practices in certification to policy makers, voluntary scheme owners, certification bodies and auditors involved in the establishment and implementation of sustainability criteria for bioenergy in the long term.

2. Method

The methodology of this study involved five steps (Fig. 2). The first step consisted of a review of sustainability criteria and sustainability verification as defined in the RED I and RED II to reveal whether the sustainability criteria have comprehensively addressed sustainability concerns. The second step was to review national legislations and voluntary schemes designed to verify bioenergy sustainability in some MSs and at EU level. In addition, in this step the similarities and differences among those systems were identified, and which systems include a comprehensive set of sustainability criteria that go beyond the RED II definitions were also revealed. Also a desk study was carried out to identify main sustainability concerns of stakeholders on bioenergy development. Based on the findings in the first two steps, the third step proposed effective sustainability criteria for the whole bioenergy sector.

The fourth step comprised a consultation with industrial stakeholders, policy makers and relevant experts. A consultation strategy following the EC guidance was established [29], which included objectives, stakeholder mapping, consultation method, time frame and language. . The consultation objectives were to (1) validate the effective sustainability criteria for bioenergy; (2) investigate the updates of sustainability frameworks in the MSs, and in voluntary schemes (3) receive opinions and vision of stakeholders on the adoption of the RED II and its transposition to national legislations. Based on these objectives, a questionnaire was developed that included sustainability reporting, sustainability criteria, and harmonised sustainability requirements (see Anne×5). To be able to fulfil the objectives, the stakeholder mapping focused on stakeholders who have a clear position and expertise of bioenergy development. The consultation method consisted of both online survey that was sent to the targeted stakeholders; and also interviews with selected stakeholders including policy makers, scheme owners, sustainability auditors, and sustainability experts.

The final step included an assessment of sustainability criteria and verification defined in various national legislations and voluntary schemes. The assessment included two parts. Firstly, a quantitative assessment was carried out to identify what sustainability criteria for what types of bioenergy were included in comparison with the proposed effective sustainability criteria. Secondly, a systematic and qualitative assessment of sustainability criteria and certification was selected. The aim of this qualitative assessment was to compare the comprehensiveness and strictness of those sustainability criteria with the proposed effective sustainability criteria; to reveal the verification and certification established in those schemes to assure sustainability compliance.

Based on the assessment outcomes, good practices in certification were identified. Recommendations were also provided for the establishment and implementation of sustainability criteria for bioenergy in

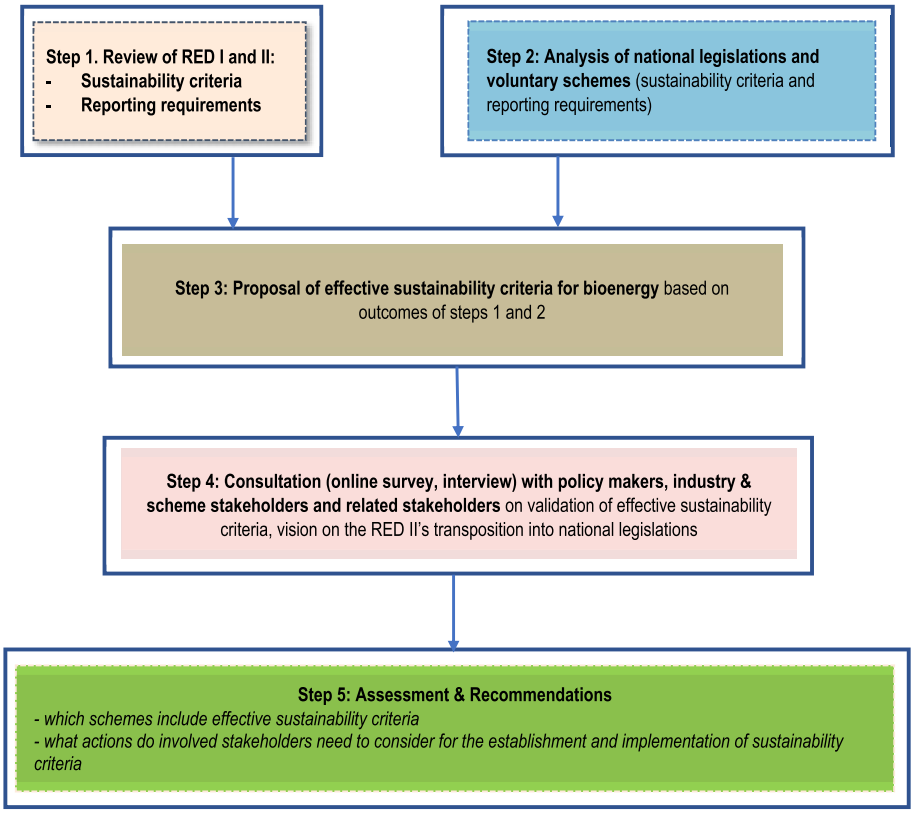

Fig. 2. Method to assess sustainability criteria for bioenergy.

MSs and in voluntary schemes.

To support the discussion on sustainability criteria which are established in MSs and in voluntary schemes, we have defined some terminology below with the help of the Oxford Dictionary and Allen et al. [30].

- **Stringent sustainability criteria** are sustainability criteria which are clearly defined without misinterpretation from stakeholders
- **Comprehensive sustainability criteria** are sustainability criteria which take into account a wide range of indicators to assure sustainability compliance
- **Efficient sustainability criteria** are sustainability criteria established in voluntary schemes or national legislations of potentially mutual recognition aiming to achieve maximum productivity with minimum administrative burdens and costs.
- Good practices in certification: To certify sustainable bioenergy, some voluntary schemes and national schemes have provided comprehensive measurements to assure sustainability compliance with defined sustainability criteria. These schemes are considered to represent good practices in certification. More details are provided in the analysis in sections 6.2 and in the conclusions.

Other terminology regarding bioenergy types and voluntary schemes is provided in Annex 1.

Step 3: Proposal of effective sustainability criteria for bioenergy based on outcomes of steps 1 and 2.

Step 5: Assessment & Recommendations.

- which schemes include effective sustainability criteria
- what actions do involved stakeholders need to consider for the establishment and implementation of sustainability criteria

Step 4: Consultation (online survey, interview) with policy makers, industry & scheme stakeholders and related stakeholders on validation of effective sustainability criteria, vision on the RED II's transposition into national legislations.

Step 2: Analysis of national legislations and voluntary schemes (sustainability criteria and reporting requirements).

Step 1. Review of RED I and II:

- Sustainability criteria
- Reporting requirements

3. Review of the RED II and identification of most urgent sustainability concerns

3.1. Overview of sustainability criteria in the RED I and RED II

A number of binding sustainability criteria for biofuels were defined in the RED I, and the definitions remain unchanged in the RED II. Some new sustainability criteria for biomass supply from forest and agriculture are established in the RED II and independent of its end use (such as biofuels, electricity, and heat). The new aspects for biomass feedstocks include LULUCF and the risk of minimisation of unsustainable production, options for sustainability compliance, and avoidance of land use impacts for forest biomass. The RED II requires higher GHG emission savings for the supply chains, which is the only criterion that is dependent on its end-use. Waste and residues only have to comply with the GHG savings requirement, but monitoring of soil quality and solid carbon is required for agricultural waste and residues. To address GHG emissions from ILUC, the ILUC Directive has established guidelines to measure low ILUC risks [31]. The RED II adds national limits for high ILUC-risk biofuels, bioliquids, and biomass fuels (produced from food or feed crops for which a significant expansion of the production area into land with high carbon stock is observed): they should remain at MSs' 2019 levels for the period 2021–2023, and then gradually decrease to zero by 2030.

Table 1 presents an overview of the sustainability criteria defined in

Table 1
Binding sustainability criteria and verification requirements for bioenergy defined in the RED I and RED II.

		RED I applied for biofuels and bioliquids	RED II applied for biofuels, bioliquids, biomass fuels
Environmental criteria:			
1	GHG emissions savings	at least 35% and 60% savings for waste and residues and for biofuels produced in installations started on or after January 1, 2017, respectively	at least 65% for biofuels, biogas consumed in the transport sector, and bioliquids produced in installations in operation from January 1, 2021; at least 70% for electricity, heating and cooling production from biomass fuels used in installations starting operation from January 1, 2021 until December 31, 2025, and 80% for installations starting operation from January 1, 2026.
2	Waste & residues	need to fulfil GHG emission savings	need to fulfil GHG emission savings and address impacts on soil quality and soil organic carbon
3	No production from land with high biodiversity value	land with high biodiversity values include primary forest and other wooded land; areas designated for natural protection, protection of rare, threatened or endangered ecosystems or species; highly biodiverse grassland	additionally include highly biodiverse forest and other wooded land
4	No production from land with high carbon stock	land with high -carbon stock includes wetlands, continuously forested land, land spanning more than 1 ha with trees higher than 5 m and a canopy cover of between 10% and 30%, or trees able to reach those thresholds in situ	No change from RED I to RED II
5	No production from peatland as of January 2008	No change from RED I to RED II	
6	Risk minimisation of unsustainable production	X	national or sub-national laws applicable for harvesting, monitoring, enforcement systems of forest biomass; or seek similar risk mitigation/ management systems
Socio- economic criteria:		not established in neither RED I nor RED II	
Verification of sustainability compliance:			
7	Land use, land use change and forestry	X	provide evidence or seek management systems to ensure that carbon stock and sink levels in the forest are maintained, or strengthened over the long term
8	Mass balance	allows consignments of raw material or biofuel with different sustainability characteristics to be mixed	clarifies further detailed information on how to measure and report mass balance

the RED I and the RED II.

3.2. Reflection on the RED II and most urgent sustainability concerns

The RED II sustainability criteria and some certain remaining sustainability gaps have been identified (see Section 1.2). In addition, socio-economic criteria are excluded in the RED II, but they are regarded as important for ensuring credible sustainability compliance [32,33]. For comparison, some common socio-economic criteria for biomass feedstocks, including labour rights, land rights, and food security, have been implemented in a number of voluntary schemes [32–34]. Some studies also indicated possible socio-economic conflicts in international sourcing regions as compliance with national and regional regulations is not easily verified [15,35]. The importance of resource-efficient use of biomass, such as waste hierarchy or cascading use of biomass, which is absent in the RED II, has also been raised by several studies [36–38]. Cascading use of biomass was considered important to maximise the cost effectiveness, minimise waste and avoid negative impacts on the environment.

3.3. Verification and certification of bioenergy sustainability

Verification and certification of bioenergy sustainability either by national schemes or voluntary schemes is important to assure that the defined sustainability criteria and GHG saving requirements in national legislations or voluntary schemes are fulfilled. Regarding the sustainability certification and verification defined in the RED II, certain concerns from the RED I implementation still remain. Some studies showed that there are large differences between the voluntary schemes recognised by the EC used to certify biofuels, not only regarding the content and strictness of criteria, but also regarding their level of assurance [39,40]. The schemes that involve various stakeholder groups on setting standards and verification, such as Better Biomass and Roundtable on Sustainable Biomaterials (RSB), provide a higher level of sustainability performance [40]. Scientific experts, exploring a more holistic understanding of sustainability, also indicated a number of specific gaps that are not sufficiently addressed in many voluntary schemes, namely resource efficiency, ILUC, risks of negative impacts on food prices and supply, and soil organic carbon [35].

Some studies also suggested that the establishment of sustainability criteria should consider not only various environmental and socio-economic aspects but also practicality of application [19,30,34,41,42]. Whilst the social and economic aspects of the European agriculture and forestry sectors (as other sectors) are regulated under the Community Charter of the Fundamental Rights, compliance is not easily determined for imported biomass to the EU [41,42]. In addition, the verification of compliance with relevant sustainability criteria helps to gain social acceptance for bioenergy development [43,44].

3.4. Proposal of effective sustainability criteria

In the previous sections, we have investigated the sustainability criteria defined in the RED II (Section 3.2), reviewed sustainability concerns of bioenergy use (Section 3.3). . Based on these section outcomes, we proposed the sustainability criteria that address the most urgent concerns and are feasible to be implemented by taking into account sustainability criteria already established in voluntary schemes and national legislations (see Table 2). We have considered the cascading use of biomass as a way of monitoring efficient resource use; however, a general definition of biomass cascading is still lacking and its effectiveness is location-, supply chain- and context-specific [36]. Nevertheless, we recommend that cascading use of biomass should at least be monitored. As ILUC criteria are not defined in the RED II, we consider the ILUC criteria following the definitions of the Delegated Regulation of ILUC risks [45]. Risk-based approach (RBA) was considered for forest biomass to assess evidence of compliance with SFM and

Table 2
Sustainability criteria and verification to assure bioenergy sustainability based on the most urgent concerns.

	Waste and residues	Agricultural biomass	Forest biomass	Compared to Red II
Environmental criteria:				
- Greenhouse gas emissions saving	✓	✓	✓	Similar
- Sustainable forest management[a]			✓	More comprehensive
- Carbon stock preservation[b]	✓	✓	✓	More stringent
- Biodiversity protection[c]		✓	✓	More stringent
- Protection of air, soil and water[d]	✓	✓	✓	More comprehensive
- Prevention of ILUC risks		✓	✓	Similar to definitions in the delegated ILUC regulation
Environmental category:				
- land use, land use change and forestry			✓	Similar
Verification of sustainability compliance:				
- chain of custody	✓	✓	✓	Similar
- risk based approach[e]			✓	Additional
Socio-economic criteria: binding to imported feedstocks[f]				
- labour rights	✓	✓	✓	Additional
- land rights		✓	✓	Additional
- food security		✓	✓	Additional
- cascading use of biomass	a monitoring of efficient biomass use			Additional

[a] Also include protection of endangered species and maintenance of ecosystems.
[b] Also consider management and logging activities maintain, possibly enhance, or restore carbon storage in the forest.
[c] Also consider operational activities avoid negative impacts on biodiversity and conservation values.
[d] Protection of air, soil, and water is proposed as a binding criterion, going beyond as indirectly assessed through EU laws and regulations: sustainable use of water resources, prevention of water pollution, sustainable management of soil, and avoidance of erosion and air pollution.
[e] Risk based approach is recommended in the RED II and it has been implemented by voluntary schemes, thus is considered as a practical approach to assess all forms of available evidence. We recommend it as an effective approach to demonstrate compliance with the SFM and carbon stock criteria when certification is not available at sourcing area level.
[f] Socio-economic criteria are not defined in the RED II but they are established in several national legislations and voluntary schemes. The identified socio-economic criteria respond to the most frequently expressed concerns of stakeholders to ensure compliance with fundamental socio-economic values.

carbon stock criteria when sustainability certification is not available. In theory, RBA could be used for agricultural biomass but since it has not yet been implemented for this biomass type, RBA was considered effective only for forest biomass. Socio-economic criteria were considered important, particularly for feedstocks mobilised in sourcing regions where local laws and rights are not implemented or not stringent enough to assure sustainability compliance.

4. National legislations and voluntary schemes

4.1. Sustainability certification and certification for liquid biofuels

Voluntary schemes recognised by the EC can be used to certify that biofuels are sustainably produced by verifying that they comply with the RED I sustainability criteria. The recognised voluntary schemes have also been accepted by MSs in order to facilitate the functioning of the internal market and show sustainability evidence. However, the sustainability criteria defined in voluntary schemes are not similar to the RED I definition as these schemes may include additional and more stringent criteria to demonstrate various pathways of sustainable biomass production and supply chains. The sustainability criteria established in the voluntary schemes recognised by the EC [46] and their additional criteria used to certify different sustainability scopes were compared with the effective sustainability criteria proposed in Table 2. We investigated how these sustainability criteria might be used to certify sustainable biofuels, but potentially also heat and electricity defined in the RED II. The assessed voluntary schemes include the International Sustainability and Carbon Certification (ISCC), Bonsucro, Round Table on Responsible Soy (RTRS), RSB, Biomass Biofuels voluntary scheme (2BSvs), Red Tractor Farm Assurance Combinable Crops & Sugar Beet Scheme (Red Tractor), Scottish Quality Farm Assured Combinable Crops (SQC), REDcert, Better Biomass, Roundtable on Sustainable Palm Oil (RSPO), Biograce tools, HVO Verification Scheme (HVO), Gafta Trade Assurance Scheme (GTAS), KZR INIG System (KZR), Trade Assurance Scheme for Combinable Crops (Trade Insurance), and Universal Feed Assurance Scheme (UFAS).

Furthermore, there are also national legislations for biofuels. The national support schemes designed to implement national legislations and verify sustainability compliance were also reviewed. The UK Renewable Transport Fuel Obligation Order (RTFO) was selected for an assessment as their sustainability guidance for involved parties is transparent and informative.

4.2. Sustainability certification and certification of solid biomass for heat and electricity

Several national legislations and industrial initiatives have established sustainability criteria and reporting requirements for heat production and electricity generation using solid biomass. The sustainability criteria are binding in related support schemes such as the UK Renewable Obligation Order for Solid Biomass (RO), Dutch Stimulation of Sustainable Energy Production (SDE+), and Belgian Green Certificates (GCs). The criteria may be also voluntary as in the voluntary initiative Danish Industry Agreement. These systems are designed to encourage the production of renewable energy from sustainable biomass, linked to specific national sustainability criteria and voluntary sustainability criteria. Economic operators can provide evidence which demonstrates a sustainability compliance with national authorities who verify the compliance proofs. As the systems in the Netherlands and the UK provide public and comprehensive guidance for bioenergy sustainability, they were assessed and compared with the RED II sustainability criteria and verification requirements.

In addition, there are also widely-used voluntary schemes for solid biomass, including the Forest Stewardship Council (FSC), Programme for the Endorsement of Forest Certification (PEFC) and Sustainable Biomass Program (SBP). The FSC and PEFC establish various types of certification. The SBP, FSC and PEFC were assessed as they certify sustainable forest feedstocks. It should be noted that the FSC and PEFC assessed in this study include the FSC Controlled Wood and Chain of Custody as well as the PEFC Controlled Sources and Chain of Custody. Three schemes are recognised by Belgium, Denmark, the Netherlands and the UK, where sustainability criteria for solid biomass have already been implemented. These schemes can be used to demonstrate compliance with environmental, socio-economic criteria for forest biomass.

5. Stakeholder consultation

The consultation was carried out from May 2018 to March 2019, with insight into the proposed RED II and adopted RED II. Invitations to

the interviews were sent to twenty selected stakeholders, seven of whom agreed to be consulted. The online surveyreceived a total of fifteen responses and seven stakeholders completed the questionnaire; consequently, seven contributions were considered. The stakeholders included policy makers from Denmark, Italy and the Netherlands; scheme owners, and industry representatives, consultants and NGOs from Austria, Belgium, Germany, Ireland, the Netherlands and Switzerland. Although the number of responses did not allow a comprehensive coverage of all stakeholders, they validated the effective sustainability criteria and provided valuable information on various sustainability aspects of bioenergy, which were useful for the studied focuses. The consulted information included among others, a validation of effective sustainability criteria, viewpoints on reporting guidance, usage and comprehensiveness of national legislations and voluntary schemes, and improvement of voluntary schemes. The consultation results showed the points on which the stakeholders agreed most.

- Validation of proposed effective sustainability criteria. The effective sustainability criteria as proposed by this study were validated by all consulted stakeholders. They agreed that these sustainability criteria are important to assure sustainability compliance and are practical enough to be implemented. The consulted stakeholders provided additional information on various sustainability aspects:
- Environmental criteria: Most of the stakeholders mentioned that it would still be complicated to apply ILUC measures in reality; therefore, the implementation of ILUC measurements still needs to be discussed among the MSs. The stakeholders agreed that inclusion of ILUC measures is necessary; but if ILUC is applied only to land used for biofuel production and not to other sectors using the same biomass, this may cause conflicts among these sectors and undermine the true meaning of sustainability compliance. The stakeholders also agreed that, in addition to the existing sustainability criteria, sustainable forest biomass use is important, and that a recognition of schemes safeguarding SFM is a positive step towards ensuring sustainability compliance. In the stakeholders' opinions, data collection of GHG emission calculation and other criteria for reporting and demonstrating sustainability is still unsatisfactory as they were deemed not completely verifiable.
- GHG emissions: The stakeholders mostly agreed that a comprehensive and flexible tool allowing the inclusion of various aspects of the biomass value chains would be useful for GHG emission calculation. For conventional biofuels, a GHG-saving requirement of 70% would probably be difficult to achieve; however, for advanced fuels, this may well be possible. Although the GHG emission reduction threshold is certainly helpful, it is insufficient to stimulate the currently still immature market of advanced biofuels.
- Socio-conomic aspects: According to the stakeholders, an inclusion of socio-economic criteria is part of good governance. They highlighted that the compliance with laws, land rights and worker rights is important and should be considered as relevant for certain feedstock use. Food security should not solely involve the biofuel industry but all the bioeconomy sectors.
- Chain of custody: Stakeholders mentioned that while mass balance is a relevant chain of custody approach, there were still some sustainability risks. For example, different biomass fuels such as wood and straw pellets have been grouped together, and it is unclear what types of fuel are categorised as waste and residues, and what types of fuel are considered product. These uncertainties make it difficult to establish what sustainability criteria should be applied to demonstrate sustainability compliance.
- Reporting guidance. The consulted stakeholders mentioned that in some MSs, guidance in sustainability reporting of biofuels, heat, and electricity was relatively clear, but that more information was needed for economic operators on how to demonstrate compliance. For biofuels, the sustainability reporting was mainly proven by certificates issued from voluntary schemes, whilst for heat and electricity a combination of direct reporting to the authority and certificates in certain countries was used. According to the stakeholders, updates on the RED II adoption had been sufficiently provided to all related parties. However, for the establishment of sustainability criteria at the national level, more details are still required for feedstock classification, environmental impacts of feedstock use, and sustainability concerns of feedstock mobilisation (particularly imported feedstocks to the EU).
- Usage and comprehensiveness of national legislations and voluntary schemes. Besides accepting certificates provided by EU-recognised voluntary schemes, the UK, Italy, and Germany allow direct sustainability reporting to demonstrate the sustainability of biofuels. The stakeholders acknowledged that the ISCC and REDcert schemes are frequently used in the EU, and they considered the RSB to be the most comprehensive scheme, with stringent sustainability requirements for biofuels. The RSB is widely recognised because of the comprehensive coverage of feedstock types and the transparent reporting system.
- Improvement of voluntary schemes. The stakeholders stated that the voluntary scheme owners, auditors and verifiers were aware of legislative guidance and changes at EU level. The EU-recognised voluntary schemes are likely to be updated and improved upon following the adoption of RED II. They also stated that most voluntary schemes still need to be more transparent in documenting sustainability verification and certification. In addition, the stakeholders emphasised that coverage of additional supply chains for bioenergy is important and needs to be further considered by the voluntary schemes.

6. Assessment of sustainability criteria and verification

The assessment focused on the most relevant aspects as listed in Table 3. Note that changes may have occurred after the assessment period, for example to address and implement the changes of the RED II. Any changes made after December 2018 have not been included in this study.

6.1. Quantitative assessment of sustainability criteria and verification

The sustainability criteria defined in Table 2 were compared to the criteria established in national legislations and voluntary schemes. It was revealed that certain schemes already cover a variety of sustainability criteria for end uses and feedstock types. The Biograce I (for biofuels) and Biograce II (for solid and gaseous biomass) tools exclusively focus on GHG emission saving criteria. It should be noted that from 2019 both Biograce tools are no longer recognised as voluntary schemes. The FSC and PEFC have been developed to safeguard SFM and wood supply regardless of the end uses of biomass. The SBP was developed to certify woody biomass supply to industrial, large-scale energy producers. Consequently, there was only a limited inclusion of sustainability requirements in the FSC, PEFC, and SBP. There were six schemes that comprise comprehensive socio-economic criteria, namely the UK RTFO, UK RO, SDE+, Better Biomass, ISCC, and RSB. The UK RTFO & RO, and SDE + schemes are well established and provide regular updates on bioenergy development and sustainability compliance. The Better Biomass, ISCC and RSB schemes include various feedstock types and comprise sustainability criteria not only for bioenergy but also for sustainable biomaterials and biochemical production. Table 3 shows the inclusion of sustainability criteria under popular national schemes and voluntary schemes used in the EU.

6.2. Qualitative assessment of sustainability criteria and verification

In the qualitative assessment, the most relevant aspects of the effective sustainability criteria were summarised and discussed.

Table 3
Inclusion of sustainability criteria in the RED I, the RED II, national legislations and voluntary schemes for liquid biofuels and solid biomass. All" stands for all types of feedstocks, "F" stands for forest feedstock, "W" stands for waste and residues, "Ec" stands for energy crops. "X" represents sustainability criteria included in the scheme but does not present strictness level.

		Policies and schemes	Feedstock coverage	Sectoral Relevance	Environmental criteria							Socio-economiccriteria			
					GHG emissions saving	SFM	Carbon stock preservation	High biodiversity protection	Protection of water resources, air & soil	ILUC	LULUCF	Worker rights	Land right	Food price & security	Resource efficiency
Liquid biofuels	1	RED I	Ec & W	T	x		x	x							
	2	RED II	All	T, H, E	x	x	x	x			x				
	3	UK RTFO	All	T	x		x	x	x			x	x		
	4	ISCC	All	T, H, E	x	x	x	x	x			x	x	x	
	5	Bonsucro	Ec	T	x		x	x	x			x	x		
	6	RTRS	Ec	T	x		x	x	x			x	x		
	7	RSB	All	T, H, E	x	x	x	x	x	x	x	x	x	x	
	8	2BSvs	Ec & W	T	x		x	x	x			x			
	9	Red tractor	Ec	T			x	x							
	10	SQC	Ec	T			x	x							
	11	REDcert	All	T	x		x		x			x		x	
	12	Better Biomass	All	T	x		x	x	x	x		x	x	x	x
	13	RSPO	Ec	T	x		x	x							
	14	Biograce I, II	All	T, H, E	x										
	15	HVO	Ec & W	T	x		x	x							
	16	Gafta	Ec	T			x	x							
	17	KZR INIG System	Ec & W	T	x		x	x							
	18	TASCC	Ec	T	x		x	x							
	19	UFAS	Ec	T	x		x	x							
Solid biomass	20	RED II	All	T, H, E	x	x	x	x			x				
	21	UK RO	F & W	H&E	x	x	x	x							
	22	SDE+	F, Ec & W	H&E	x	x	x	x	x	x	x				
	23	FSC	F	T, H, E		x	x	x	x		x	x	x	x	
	24	PEFC	F	T, H, E		x		x	x		x	x	x	x	
	25	SBP	F	H&E	x	x		x	x		x	x	x	x	

6.2.1. Greenhouse gas emission savings

In the RED II, two methods to calculate GHG emissions are defined: one method for transport fuels, biofuels and bioliquids and another method for biomass fuels used to generate electricity or to produce heat and cooling. Typical and default values (with no net GHG emissions from land use change are provided in the RED II for transport biofuels, electricity and heat from biomass. In view of the RED II requirements for GHG emissions savings, two aspects were assessed to anticipate how the higher GHG emission reduction for bioenergy can be met: (i) inclusion of additional feedstocks and (ii) inclusion of additional supply chains.

There were only six tools to calculate GHG emissions in the EU: the BiograceI and Biograce II, the ISCC tool, the RSB tool, the UK Biofuels Carbon Calculator and the Solid and Gaseous Biomass Carbon Calculator. The Biograce tools were widely used by voluntary schemes for calculating GHG emissions in accordance with RED I definitions. The ISCC and RSB have developed separate tools to calculate GHG emissions in accordance with RED I definitions, for the EU market as well as for the global market; both use Ecoinvent data for calculating GHG emissions of bioenergy and biomaterials.

The assessment revealed that the UK tools include comprehensive GHG emissions data and establish calculation methods similar to the RED II methodologies. The UK Biofuels Carbon Calculator provides a high number of default values for diverse feedstocks as well as various biofuel types. For example, it covers information of energy content and default GHG emission values (which are not available in the RED II) for biodiesel produced from animal waste or tallow. It also covers ILUC values for land-based crop biofuels. Moreover, the UK Biofuels Carbon Calculator also requires the economic operators to report emissions from fuel depots and filling stations beyond the duty points, to attain additional information on biofuel emission impacts. The UK Solid and Gaseous Biomass Carbon Calculator includes information for heat and electricity produced from diverse feedstocks, including feedstocks not defined in the RED II (such as bagasse pellets, olive cake pellets, and refuse-derived fuel). Both UK tools included a number of feedstocks that are used not only for the production of biogas, transport and advanced fuels but also for heat and electricity generation.

In principle, there are possibilities for updating calculation tools such that they take the RED II's methodologies into account. The RSB and ISCC methods are likely to be revised following the RED II updates. The UK tools are already compatible with the RED II's methodology in terms of both calculation method and system inclusion.

6.2.2. Environmental aspects

6.2.2.1. Biodiversity protection. The criteria of high biodiversity values were defined in all voluntary schemes recognised by the EC. In consideration with the effective sustainability criteria, some schemes also require a higher level of biodiversity protection including maintenance, preservation and strengthening of high biodiversity value. These schemes include the SDE+, Better Biomass, RSB, and REDcert. The FSC and PEFC include more detailed guidance and requirements. For example, the FSC requires full maintenance of retention trees (which stand permanently next to the regenerated trees to promote biodiversity), protection of endemic species as well as of rare, threatened and endangered species, and species of exceptional value. The PEFC clearly requires the prohibition of forest conversion.

The UK RO and REDcert indicate that they follow the biodiversity principles of the FSC and PEFC. The UK RTFO further recommends using internationally recognised standards for demonstrating compliance with highly biodiverse and protected areas.

6.2.2.2. Indirect land use change. The Delegated Regulation of ILUC risks define feedstocks of high ILUC risks. Biofuels, bioliquids and biomass fuels may only be certified as low ILUC-risk fuels if they comply with GHG emission saving criteria and have been produced from additional feedstock obtained through additionality measures. Those measures cover (1) increasing productivity on the land already used, (2) cultivation of crops in areas that were previously not used for cultivation of crops (unused land), provided that a financial barrier has been overcome, or the land has been abandoned or severally degraded, or the crop has been cultivated by a small farmer; and (3) robust evidence proving that (1) and (2) have been met.

There are three schemes which include low ILUC risk criteria which are, to some degrees, similar to the criteria defined in the ILUC-delegated regulation. The SDE + scheme requires low ILUC risks for biomass sourced from bioenergy plantation systems (equal or larger than 500 ha) that were planted after January 1, 2008: the ILUC risks must be determined on the basis of the Low Indirect Impact Biofuels (LIIB) method [47] or an equivalent method. The ILLB method indicates that low ILUC risk biofuels can be achieved by increasing the crop yields and/or expanding agriculture on previously non-agricultural land with low carbon stocks and low biodiversity values. The RSB defines three indicators to be assessed for low ILUC feedstocks: (1) additional biomass is produced through a yield increase; (2) biomass is produced from land that was not previously cultivated or was not considered arable land; and (3) biomass is derived from existing supply chains and does not require dedicated cultivation of arable land. The RSB defines the low ILUC criteria as optional. Better Biomass gives biomass producers three different options to reduce ILUC risk: (1) growing biomass on previously unused land; (2) increasing productivity by actions such as shortening the period that arable land is left fallow, intensifying the use of grassland, and increasing the harvest frequency on arable land; and (3) integrating existing agriculture or forestry with additional biomass production.

Since April 2019, the ILUC Directive has been implemented in seven national legislations [48]. Five other MSs have stated that they anticipate the implementation of the ILUC Directive. However, it is unclear whether MSs have involved voluntary schemes in verifying ILUC and in what way voluntary schemes have certified low ILUC risks following national ILUC legislation.

6.2.2.3. Preservation of high carbon stock - land use, land use change and forestry. The carbon stock criteria similar to the RED II definition have been established in most assessed schemes. There were some schemes that define more stringent criteria than the RED II definition and include compatible definition of carbon stock preservation with the effective sustainability criteria. The FSC scheme demands that forests are protected because of their carbon stock function: management activities must maintain, enhance or restore carbon storage in the forest, including through forest protection and reduced impact logging practices for carbon. The PEFC scheme requires (1) a consideration of positive impacts on long-term carbon sequestration capacity of forest vegetation, even with the conversion of severely degraded forests to forest plantations; (2) protective functions of forests for society, such as climate regulation and carbon sequestration; and (3) maintenance and enhancement of regulating or supporting ecosystem services.

With the LULUCF criteria, the RED II requires that the country of origin of the forest biomass (1) must be a Party to the Paris Agreement; (2) must have submitted a nationally determined contribution to the UNFCCC; and (3) must have national or sub-national laws in place, in accordance with Article 5 of the Paris Agreement.

The LULUCF criteria have been defined in five schemes in which the country level was not taken into account and the harvesting unit is considered the most important factor. The SDE + scheme requires (1) that biomass production does not result in the destruction of carbon sinks or in long-term carbon debt; (2) that the forest management unit (FMU) is managed to retain or increase carbon stocks in the medium or long term; and (3) that biomass is not sourced from stumps unless for other reasons than wood or biomass production. The SBP scheme requires that feedstock is not sourced from areas that have high carbon

stocks and that analysis is provided to demonstrate that feedstock harvesting does not diminish the forest capability to act as an effective sink or to store carbon over the long term. The Better Biomass scheme requires the preservation of important carbon sinks in the vegetation and in the soil. The SDE+ and SBP schemes use January 1, 2008 as reference date whilst the Better Biomass uses January 1, 2007.

6.2.2.4. Sustainable forest management. The effective SFM criteria include legal sourcing, maintenance of forest productivity, and ecosystem and nature conservation, biodiversity protection and protection of air, soil and water. The criteria of biodiversity protection and protection of air, soil, and water, as parts of the SFM, were assessed separately as independent criteria. This section presented other SFM assurances: legal sourcing, maintenance of forest productivity, and ecosystem and nature conservation.

Several schemes were found to include comprehensive SFM criteria that go beyond the sustainability criteria of the RED II, some are compatible or some are more comprehensive than the effective criteria. The PEFC scheme additionally requires anti-corruption measures and payment of applicable royalties and taxes. The FSC scheme encourages the efficient use of multiple products and services of forest to ensure a wide range of environmental, socio-conomic benefits. The FSC scheme requires the protection of endangered plant and animal species as well as an enhancement of important ecological cycles. The SBP scheme requires the maintenance of the health and vitality of ecosystems. The SDE + scheme considers an FSC equivalent SFM criteria. The Better Biomass scheme addresses long-term conservation of nature with associated ecosystem services and cultural values. The ISCC scheme requires a producer to be able to prove good management practices and the establishment of continuous improvement. The RSB also requires ecosystem conservation.

6.2.2.5. Protection of air, soil, and water. The protection of air, soil, and water is not yet considered a separate sustainability criterion in the RED II. In the EU, it can indirectly be assessed through the CAP, Forest Europe or national environmental regulations. However, a number of schemes certifying feedstocks from diverse sources already require this criterion as mandatory. Moreover, several schemes presented comprehensive sustainability requirements for the protection of air, soil, and water. Compliance with national laws and regulations relevant to the protection of air, soil, and water was found in the UK RTFO, FSC, Better Biomass, RSB and ISCC.

Some schemes have defined their own criteria similar to the effective sustainability criteria. The RTRS scheme requires that pollution is minimised and generated waste is managed responsibly, that expansion of soil cultivation is responsibly managed, and that natural vegetation areas along watercourses are maintained or re-established. The RSB scheme requires that operations implement practices that seek to reverse soil degradation and maintain soil health, and that they respect prior formal or customary water rights. The 2BSvs and REDcert schemes clarify in their principles that sustainable biofuels should not be made from raw material produced on land where soil, water and air have not been protected. The SDE + scheme requires that the soil quality of the FMU is maintained and if necessary improved, with special attention to coasts, riverbanks, erosion-sensitive areas and sloping landscapes.

6.2.3. Socio-economic criteria

Socio-economic criteria are not defined in the RED II, but they are established in several national legislations and schemes. The most common criteria were assessed, including worker rights, land rights, food security and cascading use of biomass.

Regarding the worker rights, the UK RTFO and RO schemes require economic operators to prove that their biomass production does not in any way adversely affect the labour laws and worker rights, and that basic working conditions are met. Safety training is also obligatory. As effective sustainability criteria of worker rights, some requirements are needed: compliance with national and local laws; or compliance with international standards and treaties related to working and employment, including child labour, forced labour, discrimination, freedom of association and the right of collective bargaining. These requirements were also found in the ISCC, Bonsucro, RTRS, RSB, REDcert, Better Biomass, FSC, PEFC, and SBP schemes. In addition, the RTRS scheme requires fair communication as well as opportunities for employments and provision of goods and services to be given to the local population. The FSC, PEFC, and SBP schemes require the maintenance or improvement of the socio-economic well-being of workers. The ISCC, RTRS, Better Biomass, SBP, and FSC schemes require a verification of human health impacts. The RTRS states that integrated crop management techniques need to be implemented to reduce impact on human health. The FSC and PEFC also require providing opportunities for employment by making use of the socio-economic functions of forests and ecological benefits whilst still securing landscape and forest size.

Land rights as an effective sustainability criterion should include a protection of indigenous and community land rights. This criterion are included in the UK RTFO and RO, ISCC, Bonsucro, RSB, SBP, FSC, and PEFC schemes. The Bonsucro, RTRS, RSB, SBP, FSC and PEFC schemes additionally state that any conflicts regarding land rights should be solved based on free prior informed consent. Water rights are included in the RTRS scheme. The FSC and the PEFC require that the legal and customary rights of indigenous peoples to own, use and manage their lands, territories, and resources are respected.

Food security is considered as effective sustainability criteria following the approach of the Food and Agriculture Organisation as "food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life". The RSB has a food security requirement, which includes a risk assessment to food security in the region as well as mitigation of any negative impacts that result from economic operations. The scheme supports local development and economic stability by holding the applicant accountable for improving the socio-economic conditions of local stakeholders affected by the operations in regions with poverty issues.

Cascading use of biomass, an approach to resource efficiency, is only required in Better Biomass; it is meant to ensure that feedstocks used for bioenergy production are raw material-efficient. A proof of compliance can be provided by a description of the material used as well as of the measures taken to foster the efficient use of raw materials.

6.2.4. Risk-based approach

We reviewed the risk-based approach (RBA) defined by the FSC that has been widely used. We recommend a similar method used to assess all forms of available evidence that indicates compliance with the SFM and carbon stock criteria when sustainability certification is not available at the sourcing area level. The RED II indicates that the RBA needs to be in accordance with the SFM principles developed under international forest processes such as Forest Europe [49] and SFM criteria are implemented through national laws or the best management practices. However, operational guidance on the verification of compliance with the RBA is not yet available under the RED II. The RBA is also already implemented under PEFC, SBP, UK RO, and SDE + schemes.

The risk assessment defined in the FSC includes risk determinations of low risk or specified risk for specific geographic areas based on the level of threat posed by forest management activities to the five controlled wood risk categories. These categories cover 1) illegally harvested wood; 2) wood harvested in violation of traditional or civil rights; 3) wood harvested from forests in which high conservation values are threatened by management activities; 4) wood harvested from areas being converted from forests and other wooded ecosystems to plantations or non-forest uses; and 5) wood from forests in which genetically modified trees are planted. Different methodologies can be used to assess, identify and designate risk, considering the likelihood and impact

of non-conformity with FSC standards and indicators. Risk designations can be determined through a risk matrix, rating both the likelihood and the seriousness of negative impact.

The PEFC also defines a management of risks for controlled sources and materials when there are substantiated concerns. On-site inspection and reports from the actors in the supply chain and in the countries in which the products have been traded are taken into account. The RBA defined in the UK RO is based on the regional risk assessment of the FSC, PEFC and other voluntary schemes. Credible and sufficient evidence must be provided to demonstrate the low risk of non-compliance for all wood fuel land, and then it can be considered legal and sustainable. At least 70% of the mix of consignments must be legal and sustainable for the consignments to be certified. Under the SDE + scheme, the RBA is performed by the biomass producer (with an FMU smaller than 500 ha), and it may cover the supply bases of several biomass producers all together. The biomass producer gathers information on identified areas that is relevant for a risk analysis with respect to the SFM requirements. The risk of non-compliance is assessed for each SFM criterion, using adequate risk analysis methods, and subsequently implementing mitigating measures if necessary. The SBP scheme requires the certified biomass producer to implement the RBA defined in the SDE + scheme.

6.2.5. Chain of custody

Both the RED I and RED II include a verification approach - mass balance which is a chain of custody (CoC). More detailed guidance is provided under the RED II. Mass balance allows mixing of consignments of raw material or fuels with differing sustainability characteristics and GHG emissions savings or different energy content, but it is necessary that sustainability compliance can still be verified. The size of the consignments and the related quantities of sustainability and GHG emissions-saving characteristics are adjusted by applying a conversion factor; the mass balance is then applied accordingly.

Mass balance is established in all assessed national legislations and voluntary schemes. Under the UK RTFO and RO, two COCs, mass balance and physical segregation are operated at the company level or at a more detailed level of granularity. The time frame is also strict under the UK schemes: parties in the supply chain need to undertake a periodic inventory of site-level carbon and sustainability data at least on a monthly basis. Parties using an EC recognised voluntary scheme will follow the time frame of that voluntary scheme. The SDE + requires that the same mass balance is applied to the group as to individual businesses. A mass balance calculation is required for each geographical site, and it may relate to a period of no more than 12 months. If a positive balance (credit for sustainability compliance) remains, that surplus may be transferred to the following period of 12 months.

The ISCC, Better Biomass, RSB, GTAS, Bonsucro, and RTRS scheme define the comprehensive guidance for the use of a mass balance system as follows: when batches with different or no sustainability are physically mixed, the sizes and sustainability characteristics of each batch remain assigned to the batches in the calculation for either mass balance or segregation; documentation on traceability and mass balance must be updated and fully accessible to the auditors. With Bonsucro, the economic operator must define the unit of certification. The RTRS additionally requires data to be valid for 24 months from the first date recorded in the system. The RSB clarifies that whenever the participating operator combines batches of certified material with different GHG emission values, they will either use the GHG emissions savings of the batch with the lowest GHG emissions savings, or track the GHG values individually. The REDcert requires mass balancing for the sum of all consignments withdrawn from the mixture to be described as having the same sustainability characteristics, in the same quantities, as the sum of all consignments added to the mixture.

The FSC requires the organisation to implement and maintain a CoC management system appropriate to its size and complexity to ensure its continuous conformity to all applicable certification requirements, and it also requires that all records are retained for a minimum period of 5 years. Regarding control of FSC claims, guidance is provided for single, multi-site and group CoC certification. The PEFC establishes two optional CoC approaches: (1) the physical separation method may apply to the certified products with various content of certified material, and (2) the percentage-based method considers material entering and leaving the group of products have the same measurement units. There is no fixed time frame for the verification of the material; instead, the PEFC requires on-site inspection to be carried out whenever relevant. The SBP defines a supply base in which feedstocks can be traced back and the feedstock input profile is described and categorised by the mix of inputs.

7. Discussion and conclusions

7.1. Discussion

This study has assessed sustainability criteria defined for bioenergy in the RED II, national legislations, and voluntary schemes. Based on the stakeholder consultation and the literature review of bioenergy sustainability and certification, there are several aspects which need to be considered further by policy makers, voluntary scheme owners and other involved parties.

7.1.1. Sustainability criteria

- Compliance with laws and regulations. Most of the national legislations and voluntary schemes include legal compliance with laws and rights in sourcing countries. Local laws may not be established, may not be stringent enough or may not be enforced, and as a result, sustainability compliance is not adequately safeguarded. For compliance with the sustainability criteria for high biodiversity values, peatland and forest biomass, it is stated in the RED II that the EC may recognise a list of protection areas defined by the International Union for the Conservation of Nature (IUCN) or defined by international agreements. The RED II provides no guidance in responding to socio-economic concerns. In case the related laws are not in effect, we recommend two lists of known international standards in Annexes 3 and 4 for the preservation of biodiversity, ecosystem values and conservation values as well as for social aspects. These standards are widely applied at global level to respond to sustainability concerns [50,51]. Policy makers and scheme owners may consider adopting those standards as proof of sustainability compliance.
- Remaining concerns about ILUC, waste and residues. The ILUC criteria are deemed important to respond to public concerns regarding the unsustainable production of biomass; since ILUC measurements have already been implemented at MS level, they were included in this study as a possible effective sustainability criterion. However, it still needs to be seen to what extent ILUC measurements help to assure sustainable land use, as little information has been given so far. The ILUC criteria have only to a limited extent been adopted in voluntary schemes, and it remains largely unclear how the ILUC criteria have been implemented in these voluntary schemes. We propose that policy makers, voluntary scheme owners and sustainability practitioners agree on measures for increasing the effectiveness of ILUC criteria, and on how to overcome challenges. It should also be noted that at EU level, the adoption of the RED II and the Delegated ILUC Regulation has initiated a World Trade Organisation (WTO) dispute between the EU and some sourcing countries [52,53]. The EU has stated that the RED II and the Delegated ILUC Regulation were established to respond to environmental concerns, while the WTO states that governments themselves have the right to deal with environmental impacts [54]. However, the WTO has not yet issued a final verdict in this dispute.

Regarding waste and residues, the RED II specifies that these feedstocks need to fulfil only the GHG emission saving requirements. Waste

and residues from agricultural land are exempted from soil quality and soil carbon criteria if monitoring or management plans that address the impacts are in place. Oil palm, soybean and sugar cane are produced in some regions that are considered to have high ILUC risks [55], thus it remains unclear how residues from these crops can meet the ILUC criteria. Using waste and residues from those feedstocks are deemed sustainable following the RED II guidance, but NGOs might disagree. Therefore, we anticipate that clarification and agreement need to be achieved by policy makers and involved parties on whether waste and residues from high ILUC risk feedstocks are eligible, and on what sustainability criteria might be relevant. Additional guidance on measuring ILUC risks and provision of consistent category of waste and residues would be helpful for actors involved in the verification and certification of sustainable feedstocks.

- Risk-based approach: The RBA is already implemented in several national legislations and voluntary schemes. However, the risk assessment differs among these systems. Whilst the scope for an RBA is stated in the SDE+, risk assessment is decided and based on sustainability concerns of controlled wood categories in the FSC, controlled sources and materials in PEFC. Therefore, selection of a relevant RBA still needs to be decided by policy makers.
- Installation capacity. The RED II defines the total rated thermal inputs for plants producing bioenergy. This requirement is in line with the capacity defined in the EU Emission Trading System and may help to minimise administrative costs for operators [56]. In reality, several MSs already require compliance for plants with a smaller capacity. In the UK, a generating station using biomass of 50 kW capacity have to report against sustainability criteria [28], and in the Netherlands, a 5 MW wood pellet steam boiler [57] also needs to demonstrate its sustainability compliance. As also indicated in the RED II, defining a threshold is permitted at MS level. Thus, we suggest that policy makers carefully consider a suitable plant capacity in their country to avoid leakage: feedstocks which do meet sustainability criteria to feed in plants of high capacity in one country might be sold to produce bioenergy in plants of low capacity in other countries.
- Relevant sustainability criteria. Binding sustainability criteria defined in the RED II are fixed for biofuels and bioliquids, but additional sustainability criteria may be established for solid biomass in MSs. The effective sustainability criteria proposed in this study and approved by consulted stakeholders are more comprehensive than in the RED II. However, too many requirements to demonstrate sustainability compliance may cause effective sustainability criteria to become ineffective. To facilitate the sustainability compliance of feedstocks mobilised in sourcing countries, policy makers and voluntary scheme owners may consider accepting stringent national legislations or stringent sustainability criteria on the protection of air, soil and water, or socio-economic compliance in certain voluntary schemes. These might be practical solutions to avoid the administrative costs of certification, and it may be less time consuming for economic operators. However, national laws and voluntary schemes that include relevant criteria compatible with effective sustainability criteria need to be discussed and assessed, ideally at EU level. The assessment helps facilitate sustainability compliance with sustainable sourcing of biomass.

7.1.2. Verification and certification

Overall, national legislations and voluntary schemes which establish comprehensive sustainability criteria for bioenergy in their systems are deemed efficient to safeguard sustainable bioenergy. Various environmental, socio-economic sustainability criteria have already been implemented in certain national legislations and voluntary schemes [27,28,57,58]. From the assessment of sustainability criteria and certification, we have found some national legislations and voluntary schemes that establish comprehensive sustainability criteria for bioenergy; that are recognised by stakeholders as good verification and certification systems. We concluded them as good practices in certification and we recommend to use them as certification models. For MSs which aim to establish stringent sustainability criteria in their national legislations for agricultural biomass, waste and residues, we recommend considering the sustainability criteria in the RSB scheme, and to a lesser extent in the UK RTFO, Better Biomass and REDcert schemes. For stringent sustainability criteria used for forest biomass, we recommend the FSC and UK RO schemes. Regarding GHG emission savings, calculations can be based on the RED II guidance, and the UK RTFO and RO schemes.

For MSs which aim to follow closely the sustainability criteria defined in the RED II, we recommend considering our summary of sustainability criteria in Table 3 and to review our qualitative assessment of various schemes in subsection 6.2. However, it is also important to note that the development of certification systems for biomass sustainability is a continuous process, changes may have happened or may still occur in these schemes.

7.1.3. Study limitations

Since the adoption of the RED II, progress has been made in transposing sustainability criteria into national legislations, and similar progress has been made in certain voluntary schemes. Nevertheless, consultation with the stakeholders in Eastern Europe, where some countries play important roles as sourcing countries of biomass, proved not to be possible. As a result, efforts to assure sustainability compliance and to certify sustainable bioenergy could not be fully investigated. It is recommended that in future research there is more communication with stakeholders in biomass-sourcing countries. The communication may better address challenges of implementing sustainability compliance, and efficient monitoring of sustainability compliance.

7.2. Conclusions and recommendations

Challenges of the RED II implementation. The RED II defines binding sustainability criteria for the whole bioenergy sector; thus, it plays an important role in safeguarding sustainable biomass and bioenergy supply in the EU in the near future. However, the RED II also presents new challenges to the transposition of sustainability criteria at MS level. These challenges include a scope extension to new end-use sectors, including heat and electricity; a scope expansion to advanced biofuels; and additional and updated sustainability criteria to agriculture and forest biomass. This study also shows that the RED II sustainability criteria are deficient in avoiding some risks of unsustainable forest management, lack stringent protection of air, soil and water resources, and lack socio-economic criteria that are relevant for biomass feedstocks imported to the EU. The transposition and implementation of the RED II will be difficult without detailed guidance on certain sustainability criteria and their indicators.

Effective sustainability criteria. In this study, we propose effective sustainability criteria to tackle the most urgent sustainability concerns that are not addressed in the RED II. The effective sustainability criteria for waste and residues involve GHG emission savings; carbon stock preservation; protection of water, soil and air, which also addresses soil quality and soil carbon impacts; and labour rights. The effective sustainability criteria for agricultural biomass should include, next to the criteria for waste and residues, biodiversity protection, prevention of high ILUC risks, land rights and food security. The proposed biodiversity protection criteria are more stringent than defined in the RED II, whilst land rights and food security are not included in the RED II. The effective sustainability criteria and requirements are most stringent and comprehensive for forest biomass: in addition to the previous criteria, they further include the SFM criteria, a LULUCF reporting requirement and risk-based approach. The SFM criteria are more stringent whilst the LULUCF reporting requirement is similar to the definitions in the RED II. Reporting cascading use of biomass has been considered, but it was not deemed effective since there has been no agreement yet on a consistent

definition nor how it can be effectively be implemented. We recommend that policy makers and voluntary scheme owners to consider our proposed effective sustainability criteria in transposing sustainability criteria of the RED II into national legislations and voluntary schemes.

Our study also finds that it is possible to establish effective sustainability criteria for various bioenergy types. However, the systems most recognised by policy makers and involved parties still need to be agreed upon and legitimised. Recognition of voluntary schemes by national authorities may increase the legitimacy of certification, trigger further efficiency of sustainability compliance, and stimulate further implementation of effective sustainability.

Future certification efforts should take into account other criteria that are widely recognised by policy makers and the scientific community for their importance and relevance, in particular for addressing socio-economic problems. To this end, the criteria proposed in the Sustainable Development Goals could be used as a guideline. The set of criteria should be extended to include criteria reflecting social capacity and institutional development.

Perspective of sustainable bioenergy and bioeconomy. To establish legislation for bioenergy sustainability, mutual discussion among policy makers on various definitions and measurements of sustainability criteria are very important. The discussion should aim to avoid emission leakage, impacts to biodiversity and ecosystems, socio-economic conflicts and trade barriers among MSs. With new sustainability criteria for the whole bioenergy sector defined in RED II, existing voluntary schemes may consider expanding their certification scope, revising the existing sustainability criteria, and/or recognising other voluntary schemes to facilitate sustainability compliance. To a higher level of assuring bioenergy sustainability than the RED II indication, policy makers in MSs are also advised to work with voluntary scheme officers and the scientific community. This will help to clarify pending sustainability concerns, and will promote the establishment and implementation of sustainability criteria in a transparent and consistent way.

Bioenergy is part of the wider bioeconomy which involves various sectors such as biomaterials and biochemicals. Binding sustainability criteria established for the bioenergy sector but not for other sectors using the same feedstocks may provoke leakages and trade-offs between sectors as well as debates on a meaningful sustainability performance. One example is that certified feedstocks may be used for bioenergy production whilst uncertified feedstocks are used for the production of biomaterials, biochemicals and feed. The sustainability aspects that must be considered in order to assure sustainability compliance among these sectors need to be agreed upon by the stakeholders involved. An example may be the question how multifunctionality must be dealt with for biorefineries using biomass feedstocks and producing multiple outputs including bioenergy. More collaborations between stakeholders from different sectors are indispensable for exchanging information and sharing the lessons learnt in demonstrating sustainability performance.

There is little time left before the RED II will come into force on January 1, 2021, and therefore communication between the involved stakeholders needs to be carried out efficiently and promptly.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

This paper was written within the framework of the ADVANCE FUEL project (http://www.advancefuel.eu/). This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement number 764799. The authors would like to express their appreciation to the project consortium and stakeholders who have made contributions to this study. Special thanks go to the external stakeholders who have answered the online questionnaire, and Cristina Mestre (Transport & Environment), Eric van den Heuvel (Platform Duurzame Biobrandstoffen), Peter Willumsen (Danish Energy Agency), Rainer Janssen (WIP-Munich), Sascha Wuestenhoefer (ISCC), Elke van Thuijl and Timo Gerlagh (RVO).

Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.rser.2020.110645.

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