Sequential silage crops as advanced feedstock under the EU RED II

A Gas for Climate paper

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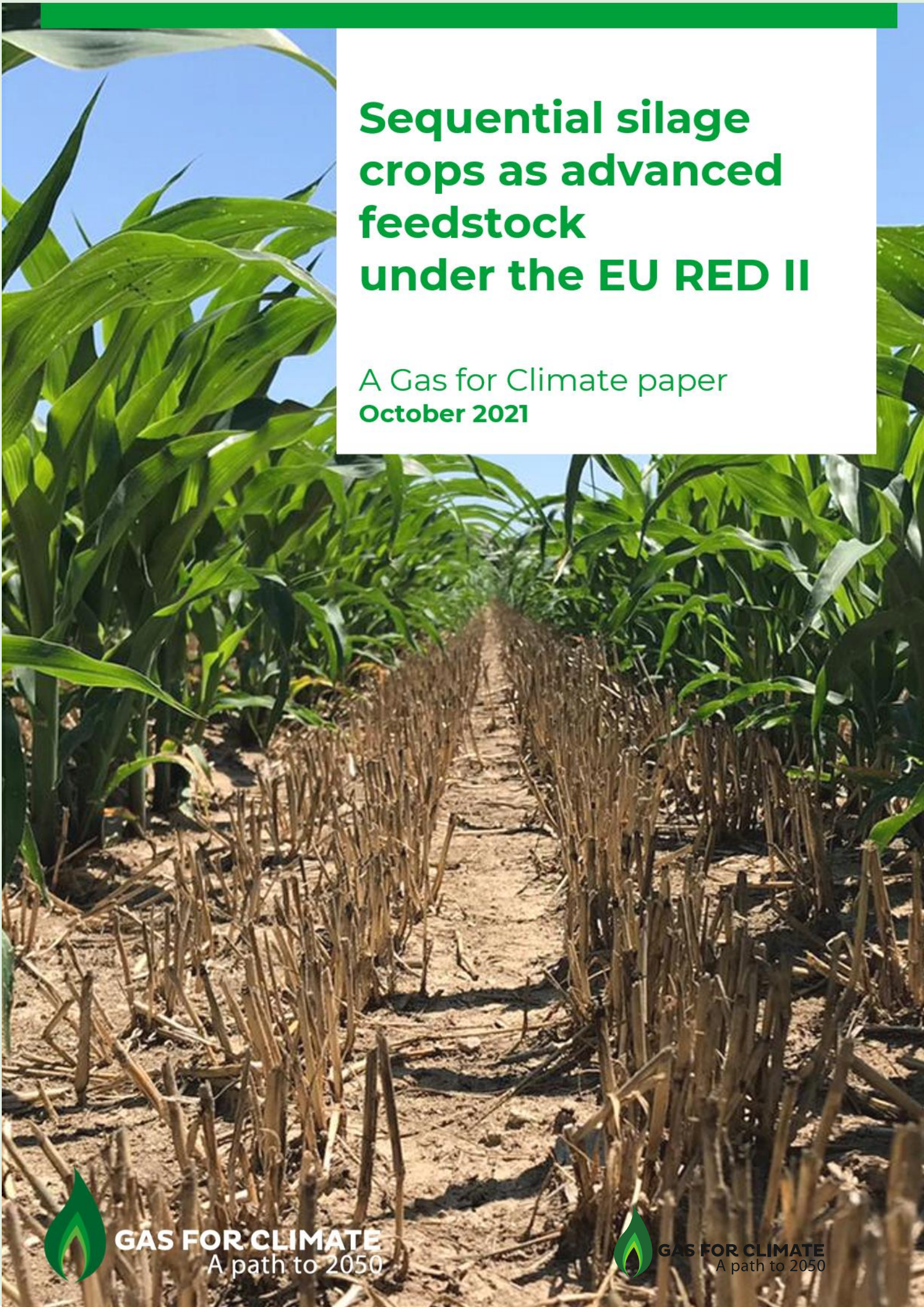

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A path to 2050

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Executive Summary

This paper explores whether **silage crops grown in a sequential cropping system**, as cultivated in Europe, would meet the evaluation criteria for 'advanced feedstock' as included in Annex IX of the recast EU Renewable Energy Directive (REDII). Being included in Annex IX would make the feedstock eligible to be double counted towards renewable transport targets and would give a clear signal about the sustainability of this cropping system.

Silage crops are harvested early in a sequential cropping system, meaning they are not fully matured crops. This enables them to be produced in combination with a main crop on the same plot of land without lowering the yield of the main crop. This practice therefore increases the overall output of existing agricultural land. Sequential cropping can be applied in a sustainable way, compliant with EU sustainability criteria for bioenergy feedstocks and not leading to negative environmental impacts under European climatological conditions.

This paper explains a feasible model for sustainable silage crops in line with Article 28(6) of the REDII. Points of attention can be water, soil, and biodiversity to ensure that sequential cropping leads to more agricultural output whilst not negatively impacting the environment. However, it is shown that the model as implemented under 'Biogasdoneright' can assure no negative impacts and can even lead to positive impacts.

The paper concludes that silage crops grown in a sequential cropping system are a good match with the evaluation criteria set out in Article 28(6), paragraph b of the EU REDII. These criteria are used by the European Commission to assess whether feedstocks should be included as 'advanced feedstocks' in Annex IX. The Gas for Climate consortium therefore recommends including silage crops grown in a sequential cropping system in the Commission's next revision of Annex IX.

1. Introduction

Biomethane has the potential to play a valuable role in achieving Europe's climate targets. A large energy system value is associated with an increased future use of biomethane as a dispatchable, storable form of renewable energy alongside large quantities of variable renewable electricity. The sustainable scale-up potential of biomethane and its energy system value has been analysed in the study 'Gas for Climate. The optimal role for gas in a net-zero emissions energy system' published in 2019.[1]

Biomethane can be produced from many types of biomass. An increasingly large share of biomethane is produced from waste and residue feedstocks, as the Gas for Climate Market State and Trends report (published in 2020[2]) showed. While biomethane production can continue to grow based on remaining available waste and residue materials, there is also a large potential to produce **sustainable biomethane from agricultural crops cultivated in sequential cropping systems**. Sequential cropping is the production of a second crop before or after a main crop on a plot of agricultural land, thereby reducing the period during which this land is fallow[3]. Its contribution towards a sustainable biomethane potential can be significant (see Figure 1), accounting for an estimated two-thirds of the biomethane potential from anaerobic digestion in the 2019 Gas for Climate study.

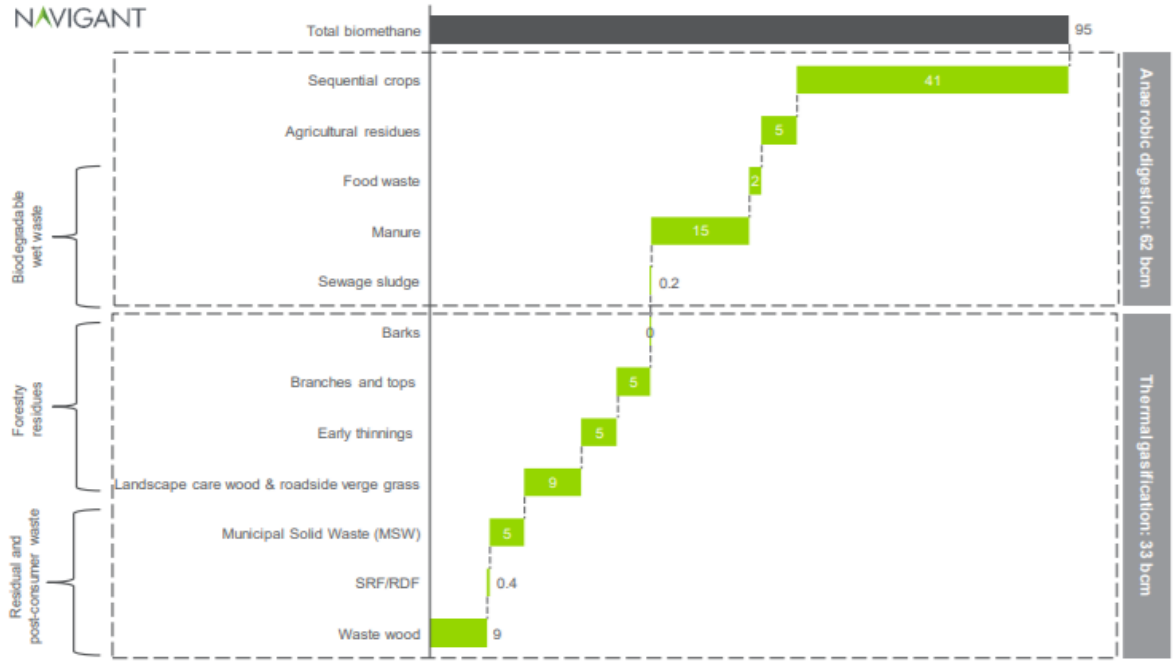

Figure 1: EU biomethane potential per conversion technology and feedstock (in bcm natural gas equivalent) type by 2050, showing sequential cropping contribution of 41 bcm. Source: 'Gas for Climate: The optimal role for gas in a net-zero emissions energy system'[4]

[1] The study can be accessed here: https://gasforclimate2050.eu/wp-content/uploads/2020/03/Navigant-Gas-for-Climate-The-optimal-role-for-gas-in-a-net-zero-emissions-energy-system-March-2019.pdf

[2] The study can be accessed here: https://gasforclimate2050.eu/wp-content/uploads/2020/12/Gas-for-Climate-Market-State-and-Trends-report-2020.pdf

[6] Article 2 (40) of the RED II states that: *'food and feed crops' means starch-rich crops, sugar crops or oil crops produced on agricultural land as a main crop excluding residues, waste or ligno-cellulosic material and intermediate crops, such as catch crops and cover crops, provided that the use of such intermediate crops does not trigger demand for additional land'.*

[3] The terms 'secondary crop' or 'cover crop' are also sometimes used interchangeably in this context.

[4] The study can be accessed here: https://gasforclimate2050.eu/wp-content/uploads/2020/03/Navigant-Gas-for-Climate-The-optimal-role-for-gas-in-a-net-zero-emissions-energy-system-March-2019.pdf

Sequential cropping is applied in several contexts around the world. For example, in South America, sequential cropping systems are able to produce two main crops. In Europe, climatological conditions would not normally allow for two main crops to be produced. However, for biomethane production, **silage crops**[5] can be cultivated as a second crop. These are typically cereal crops such as maize or triticale that are harvested early, before reaching full maturity, and therefore with a relatively short growing season. Sequential cropping of silage crops is being implemented at some scale in Italy especially, while in France a large pilot project is underway. Sequential cropping is a form of agricultural intensification and therefore it is important to ensure that this intensification is done in a sustainable way. If done in the right way, sequential cropping can even have positive environmental impacts.

The EU Renewable Energy Directive has been highly successful in driving a large increase in renewable electricity, yet far less so in scaling-up renewable gas. EU biomethane production stands at around 2.5 bcm or 25 TWh today, far below its sustainable potential. Sequential cropping is excluded from the 'food and feed cap' in the RED II[6]. This means that the Directive doesn't limit the contribution from biomethane produced from sequential cropping to count towards achieving renewable energy in transport targets.

One important practical step to drive the growth of biomethane in the EU would be for the Commission to explicitly recognise the sustainability of sequential cropping of silage crops within the EU. An option could be to include **sequential cropping of silage crops that do not impact the yield of the main crop**, in the RED II Annex IX list of 'advanced' biofuel and biogas feedstocks. This would provide an important incentive to the growth of the EU biomethane sector.

The RED II states that the Commission can evaluate the possible inclusion of new feedstocks to the Annex IX list. Article 28(6) paragraph 2 states:

*"The Commission is empowered to adopt delegated acts in accordance with Article 35 to amend the list of feedstock set out in Parts A and B of Annex IX by adding, but not removing, feedstock. Feedstock that can be processed **only with advanced technologies** shall be added to Part A of Annex IX. Feedstock that can be processed into biofuels, or biogas for transport, with **mature** technologies shall be added to Part B of Annex IX."*

It is understood that the European Commission intends to evaluate before the end of 2021 whether it would wish to include new feedstocks in Annex IX. For any new feedstocks to be included, the Commission will have to conclude that the requirements for inclusion as laid down in Article 28(6) of the RED II have been met.

This paper assesses whether **silage crops produced in a sequential cropping system**, as cultivated in the EU, would meet the criteria as listed in Article 28(6) of the RED II and could therefore be added to Annex IX. Sequential cropping is implemented in various parts of the world. In Europe in particular, the concept focuses on silage crops that require a reduced cultivation period and are harvested before full maturity.

[5] 'Silage' is the product of a forage conservation technique which is carried out by acidification of the vegetable mass. The whole plant is chopped, compacted and finally sealed in a container to avoid contact with oxygen from the outside.

2. Biomethane production with silage crops

2.1 Sequential cropping and current status

A definition of sequential cropping is given by Andrews and Kassam (1976)[7]:

"Growing two or more crops in sequence on the same field per year. The succeeding crop is planted after the preceding crop has been harvested. Crop intensification is only in the time dimension. There is no intercrop competition. Farmers manage only one crop at a time in the field."

In a sequential cropping system, land that is normally fallow between the growth cycles of the main crops is now used to grow a second crop. This second crop can then be used for the production of biomethane. The benefit of sequential cropping is that, as long as the yield of the main crop is not affected, no additional land is needed for to grow these energy crops. At the same time, no land is taken from the main crop as the crop intensification is only in the time dimension. Today in Europe, sequential cropping practices for the cultivation of energy crops takes place mainly in Italy and France, as explained below.

'Biogasdoneright' in Italy

The Consorzio Italiano Biogas (CIB) is a consortium of Italian farmers that produce biogas using different agricultural feedstocks, including crops, manure and residues. To the extent crops are used to produce biogas, producers rely on a sequential cropping system, where winter cover crops are grown on land that is left fallow after the harvest of the main crop in summer. These winter cover crops are energy crops that are used in an anaerobic digestor (AD) to produce biogas. CIB coined the term Biogasdoneright to describe their process.

Biogasdoneright focuses on producing biogas and biomethane from a mix of agricultural wastes, residues and sequential crops. Tillage of cropland is kept to a minimum (strip tillage) to increase soil carbon. The wet fraction of biogas digestate is brought back to the cropland using drip-feeding systems, which allows all nutrients from biogas crops to be recycled back to agricultural soils, thereby minimising the need to use synthetic fertilizers. The drip-feeding systems are also used for water-efficient drip-irrigation during summertime.

Biogasdoneright is multi-feedstock technique, meaning that multiple feedstocks can be used. Mostly cool-season grasses are chosen as secondary crops, with highly active photosynthetic periods before or after the growth of the main crops (Dale et al, 2016).[8] The Italian farmers of CIB mostly used triticale and sorghum as cover crops, which are both starch-rich cereals. In figure 1, an example of sequential cropping is depicted where triticale silage is used as a cover crop.

[7] http://www.fao.org/3/t0742e/T0742E06.htm

[8] Dale et al., 2016, Biogasdoneright: An innovative new system is commercialized in Italy

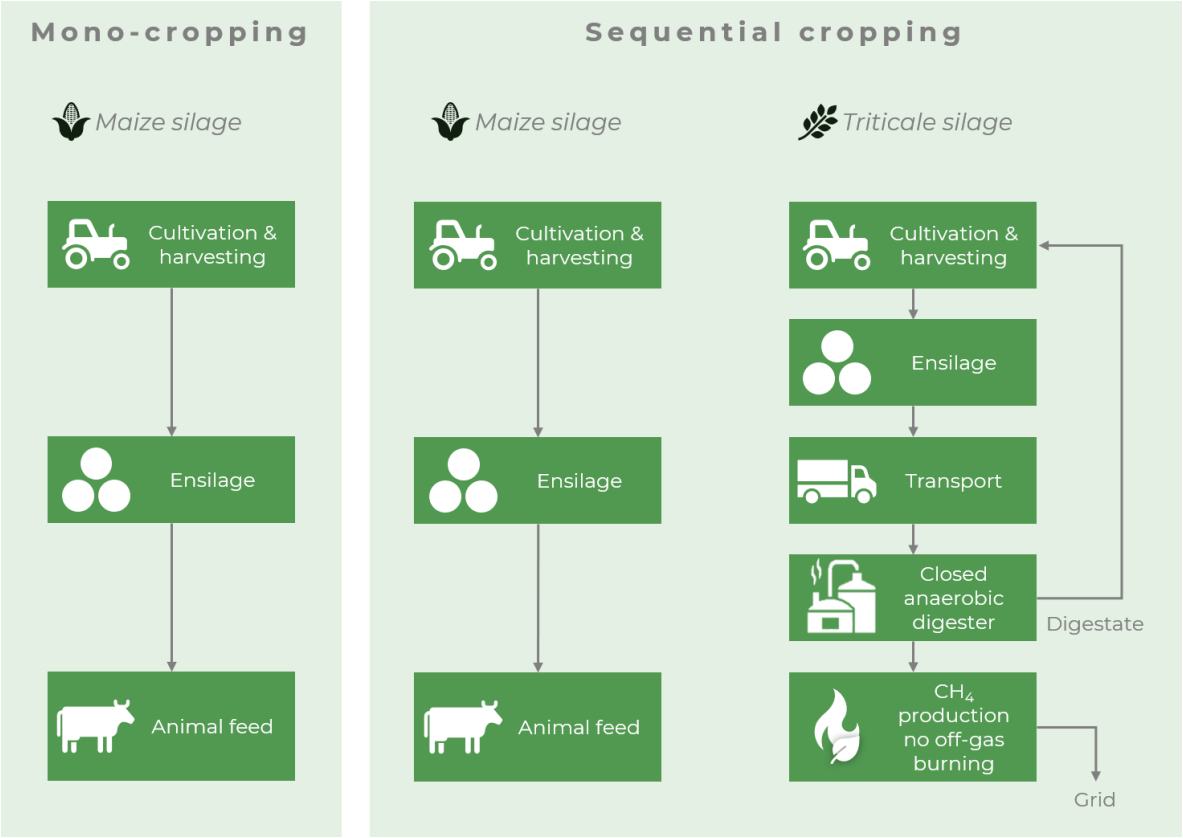

Figure 2: Comparison mono-cropping and sequential cropping for production of biogas[9]

In a conventional mono-cropping system, a large part of the agriculture land is not in use during a long period of the year. The growth of secondary crops increases the usage of the land, covering the land with biomass for most of the year. This leads to an increase of the total amount of biomass that is grown on a farm plot.

By growing both food/feed crops as well as bioenergy crops, the farmer also shields itself from fluctuating commodity prices. Low commodity prices have a negative effect on the farm income. By diversifying the markets of the crops, farmers can mitigate the market fluctuations and create additional income. In this way, food and fuel are not opposing forces but complementary products.

Sequential cropping research project led by Arvalis in France

Arvalis is an agricultural consultancy company that advises the agricultural and food sectors. They are currently managing the 'RECITAL' project in France, funded by French government agency ADEME, in which sequential cropping is applied to produce energy crops. The aim of the project is to gain insights on sequential cropping in order to optimize its application. The project focuses on triticale (a starch-rich cereal crop) as a winter crop. The project started in 2020 and will continue until 2023. Alongside Arvalis the Association of Biogas Farmers of France (AAMF) and the Chambers of Agriculture and other French economic operators are involved in the project.

[9] Ecofys (2016). Assessing the case for sequential cropping to produce low ILUC risk biomethane. https://www.consorziobiogas.it/wp-content/uploads/2017/02/Ecofys_Assessing-the-benefits-of-sequential-cropping-for-CIB_Final-report.pdf

2.2 **Sequential silage crops**

In Italy and France, farmers that apply sequential cropping focus on starch-rich silage crops because they are the most productive crops among those most suitable for biogas. The RED II defines starch-rich crops in Article 2(39) as:

"crops comprising mainly cereals, regardless of whether the grains alone or the whole plant, such as in the case of green maize, are used; tubers and root crops, such as potatoes, Jerusalem artichokes, sweet potatoes, cassava and yams; and corm crops, such as taro and cocoyam;"

This paper focuses on analysing the extent to which **silage crops, grown in a sequential cropping system**, could be classified as advanced biofuel or biogas feedstock on the basis of the criteria set out in RED II Article 28(6).

Depending on the climatic and biogeographical conditions of a region, different sorts of energy cover crops can be grown. In the Biogasdoneright setting in Italy, the most used cover crops are sorghum and triticale, both starch-rich cereals.[10] The choice for winter or summer energy cover crops depends on the cultivation period of the main crop.

Sequential cropping in the EU focuses specifically on silage crops. These are crops that are produced for the purpose of biogas production or animal feed and are harvested **before the grains are fully matured**, thereby requiring a shorter cultivation period. This means that the cultivation of silage crops as a sequential crop **does not impact the growing season of the main crop**. The European climatological conditions would usually not enable the cultivation of two fully matured food crops on the same plot of land during a year.

[10] Sorghum is a crop that can grow perfectly on fallow land and is ideally planted in late spring. The plant thrives ideally in warm, dry climates and is characterized by its very efficient use of water and nutrients. Triticale is another crop that is often used for the production of biogas and biofuels. It is a hybrid plant of rye and wheat that is also categorized as a cereal. Triticale is ideally a winter crop with its planting season late winter, with a harvesting season between May and August.

3. Assessing sequential silage crops against Art 28(6)

The Commission allows new feedstocks to be added to Annex IX Parts A or B, if these feedstocks comply with the evaluation criteria, listed (a) to (f) under RED II Article 28(6).

Table 1: Evaluation criteria for inclusion of new feedstocks in Part A or B of Annex IX

	Evaluation criteria
(a)	*the principles of the circular economy and of the waste hierarchy established in Directive 2008/98/EC;*
(b)	*the Union sustainability criteria laid down in Article 29(2) to (7);*
(c)	*the need to avoid significant distortive effects on markets for (by-)products, wastes or residues;*
(d)	*the potential for delivering substantial greenhouse gas emissions savings compared to fossil fuels based on a life- cycle assessment of emissions;*
(e)	*the need to avoid negative impacts on the environment and biodiversity;*
(f)	*the need to avoid creating an additional demand for land.*

The sections below will evaluate to what extent silage crops grown in a sequential cropping system, as cultivated for biogas in Italy and France, would meet each of the evaluation criteria.

3.1 Evaluation criteria a - circular economy and waste hierarchy

RED II Article 28(6), point (a) states that the feedstock has to take into account:

> *"the principles of the circular economy and of the waste hierarchy established in Directive 2008/98/EC"*

The principle can be divided into two subcategories:

- Complying with the waste hierarchy
- Following the principles of the circular economy

Waste hierarchy

The waste hierarchy is summed up in Article 4(1) of Directive 2008/98/EC and follows the preferred action of waste treatment (see figure 2).

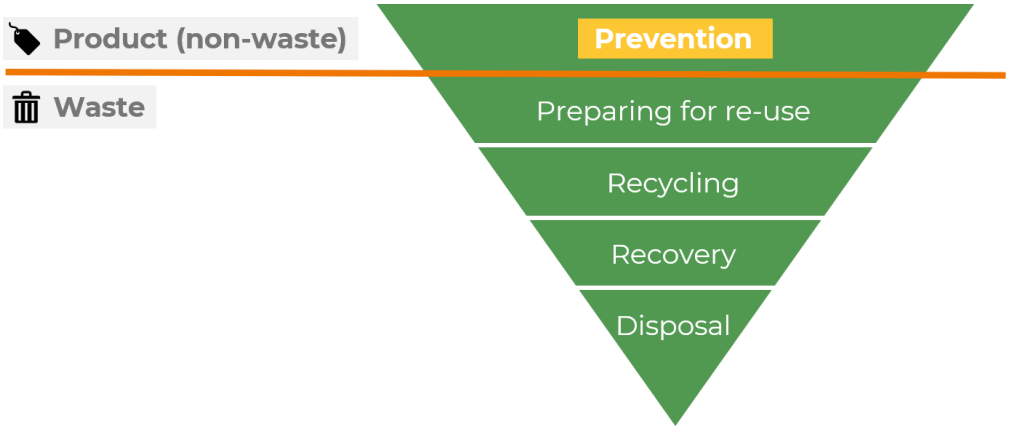

Figure 3: Waste hierarchy from directive 2008/98/EC[11]

The feedstocks used in the sequential cropping system are crop-based feedstocks and are not categorized as waste. Therefore, the principles of the waste hierarchy are de facto fulfilled as the feedstock is not a waste. By using fallow land to grow cover crops, an additional, new 'product' is created. Furthermore, all by-products that are created when producing the biogas are fully used again in new applications. The only residue resulting from the anaerobic digestion is called digestate, which can be used as an organic fertilizer for crop production.

Circular economy

With regards to the principles of the circular economy, sequential cropping of energy cover crops is regarded to follow the principles of the circular economy. The European Commission defines a circular economy as follows[12]:

"A circular economy aims to maintain the value of products, materials and resources for as long as possible by returning them into the product cycle at the end of their use, while minimizing the generation of waste. The fewer products we discard, the less materials we extract, the better for our environment."

The concept of circularity is difficult to apply to an energy carrier as most of the energy crop is transformed into biogas and afterwards combusted for energy purposes. However, the production of biogas from cover crops does minimize the waste production by using the digestate as an organic fertilizer for crops. The nutrients (and a part of the carbon content) of the original cover crop are retained in the digestate. When the digestate is applied as a fertilizer for crop production, both for energy cover crops and for main food/feed crops, a circular loop is created. Furthermore, the use of digestate as fertilizer avoids the use of fossil-based fertilizer, which benefits the circular economy.

In the introductory text of the RED II under point 21 it is also mentioned that the principles of the circular economy and the waste hierarchy should be followed "... in order to avoid unnecessary distortions of raw materials markets". As the crops are grown in a sequential cropping system for energy purposes, an additional product is created on previously unused land. Therefore, there is no distortion of raw material markets.

Conclusion: Principle (a) confirmed

[11] Source: https://ec.europa.eu/environment/waste/framework/t
[12] Source: https://ec.europa.eu/eurostat/web/circular-economy

3.2 Evaluation criteria b - sustainability criteria

RED II Article 28(6) point (b) refers to the sustainable practice of using feedstocks for bioenergy purposes and is stated below:

> *"the Union sustainability criteria laid down in Article 29(2) to (7)"*

The Union sustainability criteria referred to focus on feedstocks coming from land that has not been converted from highly biodiverse lands, high carbon stock lands or peatlands, as well as covering criteria that are specific to agricultural residues or forestry biomass. The land conversion criteria (Article 29(3)-(5)) are most relevant here as sequential crops would not be considered agricultural residues or forest biomass.

Compliance with the land-related sustainability criteria in Articles 29 (2) to (7) can be assumed when the activities and procedures of a biogas producer are officially audited and certified to an EC-recognized voluntary scheme. When a farm that produces the biogas is officially certified, the sustainability criteria of point (b) are satisfied. Any farm producing feedstock for biofuel consumed in the EU has to comply with the EU RED II sustainability criteria. Most do so through being certified to a recognized voluntary scheme. Farms practicing sequential cropping are no different to other farms producing crops for biofuels from the perspective of the land-related sustainability criteria in Articles 29(2) to (7) so there is no reason that such a farm could not be certified. In Italy, several farms who apply the Biogasdoneright concept are in the process of getting certified, with audits being performed by CSQA.

Conclusion: Principle (b) confirmed

3.3 Evaluation criteria c - market effects

RED II Article 28(6) point (c) states the following:

> *the need to avoid significant distortive effects on markets for (by-)products, wastes or residues;*

The background of Evaluation criterion (c) is the desire to avoid the risk that using crops for bioenergy would limit the supply of biomass available to satisfy demand for food and feed products, which could lead to displacement effects. The core aim of the concept of sequential cropping is to increase agricultural production sustainably, without requiring additional agricultural land. Therefore, rather than reducing the availability of food and feed crops, sequential cropping results in additional agricultural production beyond existing agricultural production. This increase in agricultural supply could lead to reduced price levels of agricultural commodities, leading to more affordable food, feed and energy crop prices.

Conclusion: Principle (c) confirmed

3.4 Evaluation criteria d – greenhouse gas savings

RED II Article 28(6) point (d) states the following:

> *the potential for delivering substantial greenhouse gas emissions savings compared to fossil fuels based on a life- cycle assessment of emissions;*

In the RED II, the minimum GHG saving threshold required for a biofuel or biogas to count towards EU renewable energy targets varies depending on the age of the installation in which the biogas is produced. The threshold ranges from 50-65% (Article 29(10)). The rules for the calculation method of the GHG savings of biogas production and use can be found in part B of Annex VI of the RED II. The method is based on a life cycle assessment of the GHG emissions of the biogas, using disaggregated values to fully account for all emissions in the lifecycle. In case of the usage of multiple substrates in the anaerobic digestor, different weights are given to the substrates. In the case of sequential cropping with silage crops, manure is often added as input for the anaerobic digestor.

Part A of Annex VI of the RED II provides the typical (and default) values for the GHG savings for different methods of biomethane production. Depending on the ratio of manure and crop input, the GHG savings vary. In a scenario of a close digestate and off-gas combustion with a manure-maize ratio of 60-40%, the GHG savings will be 90%.[13] In this case the GHG savings requirement would be fulfilled.

When the digestate, that is created as a by-product in the anaerobic digestor, is applied to crops as a fertilizer, part of the carbon that originates from the initial crop is stored back into the soil. The use of manure decreases the GHG emissions even further due to the avoided emissions of stored raw manure in open ponds.[14] When accounting for all these practices, the production of biomethane using a sequential cropping system can actually function as a bioenergy carbon capture and storage (BECCS) system as carbon is stored in the soil to create negative emissions.[8]

Conclusion: Principle (d) confirmed

3.5 Evaluation criteria e - environment and biodiversity

RED II Article 28(6) point (e) states the following:

> *the need to avoid negative impacts on the environment and biodiversity;*

Soil quality

There are indications that the implementation of sequential cropping on fallow land has multiple environmental benefits[15]. The increased coverage of the agricultural land with cover crops decreases soil erosion covering the usually bare land with vegetation. The implementation of strip tillage compared to conventional tillage keeps more nutrients and carbon in the soil. Digestate that is created as a by-product in the production of the biogas can be applied to the farmland, replacing

[13] Compared to a fossil baseline of 94 gCO2eq/MJ

[14] ART Fuels, Position Paper: Biogas Done Right in transport: Sequential cropping to produce food, feed and biomethane

[15] Sainju UM (2016) Can Novel Management Practice Improve Soil and Environmental Quality and Sustain Crop Yield Simultaneously? PLoS ONE 11(2): e0149005. doi:10.1371/journal.pone.0149005

chemical fertilizers that are likely to have negative impacts on soil quality[16]. The solid fraction of the digestate can be further developed into biochar, a stable form of carbon in the form of charcoal that can be used as fertilizer as well and adds value to soils suffering from erosion and low fertility.[17]

Sequential cropping is a form of agricultural intensification and therefore it is important to ensure that this intensification is done in a sustainable way. To guarantee that soil quality is ensured for the purpose of compliance with RED Article 28(6), point b, there could be a requirement that for the purpose of producing 'advanced feedstock' as recognised by the EU RED, sequential cropping operations should reduce or maintain the use of chemical fertilizer at the same level over the full cropping cycle as compared to the situation prior to the introduction of sequential cropping. Using biogas digestate as fertilizer should be standard practice.

In addition, sequential cropping operations should ensure that the soil is not degraded by the introduction of sequential cropping. The LANDUM C-factor values[18] for the operation should not be higher than before the introduction of sequential cropping. To this end, farmers should use soil management best practices, such as no tillage or strip tillage and leaving residues in the field (roots and stubble at 7.5-10 cm after harvest), in addition to the cover crop used in the crop rotation.

Air quality

Sequential cropping does not lead to emissions to air and therefore doesn't impact air quality.

Water usage

Due to the increase in crop production, as previously fallow land is now cultivated, water usage increases. Depending on the region and the crop, this exact extra amount of water can vary, for example, in most cases in Europe, winter sequential crops are not irrigated. In the Biogasdoneright system, a drip irrigation system is implemented which limits the water usage and increases the efficiency and precision of irrigation.[17] Using sprinkle irrigation, no increase in water consumption took place in Biogasdoneright.

In addition, in the Biogasdoneright situation, the liquid by-product from the anaerobic digester was used for irrigation to provide water and mineral nutrients, as well as the solid by-product from the digester being applied to the soil to improve soil carbon and soil fertility. This led to a reduction in chemical fertilizer costs and an improvement in water quality.

In the Biogasdoneright example, sequential cropping did not increase water requirements as the region is humid. However, this may be an issue in other locations. Further research is recommended to show the effects from sequential cropping on water usage.

To ensure that the introduction of the sequential crop does not significantly affect water usage in a crop rotation, it is recommended that the operations must have sprinkle or drip irrigation of sub-irrigation systems in place.

Biodiversity

The coverage of the fallow land by cover crops can create positive effects for biodiversity as animals can more easily take refuge on covered land compared to fallow land. The introduction of a cover crop is linked to a more biodiverse environment[19]. Moreover, as fallow land is used for bioenergy cropping, no additional land is needed for bioenergy purposes, thereby preventing pressure on the agricultural system for land conversion which can cause biodiversity (or carbon stock) losses. No negative impacts on biodiversity from the introduction of sequential cropping are known.[17]

[16] Pastorelli, R.; Valboa, G.; Lagomarsino, A.; Fabiani, A.; Simoncini, S.; Zaghi, M.; Vignozzi, N. Recycling Biogas Digestate from Energy Crops: Effects on Soil Properties and Crop Productivity. Appl. Sci. 2021, 11, 750. https://doi.org/10.3390/app11020750

[17] CIB, 2020, Biogasdoneright: Anaerobic digestion and soil carbon sequestration. A sustainable, low cost, reliable and win win BECCS solution, p21

[18] Defined in "Estimating the soil erosion cover-management factor at the European scale", Panagos, P., Borelli, P., Meusburger, K., Alewell, C., Lugato, E., Montarella, L., Land Use Policy, 2015

[19] de Pedro, L.; Perera-Fernández, L.G.; López-Gallego, E.; Pérez-Marcos, M.; Sanchez, J.A. The Effect of Cover Crops on the Biodiversity and Abundance of Ground-Dwelling Arthropods in a Mediterranean Pear Orchard. Agronomy 2020, 10, 580. https://doi.org/10.3390/agronomy10040580

Biogasdoneright has found that thanks to prolonged land cover and the improved health of the soil, the use of pesticides per hectare does not increase, but rather, depending on the crop year, often decreases with the introduction of sequential cropping.

To avoid any negative impact on biodiversity, operations replacing monocultures should reduce or maintain the use of pesticides at the same level prior to the introduction of sequential cropping, over a full cropping cycle. This should ensure that the impact on biodiversity due to pesticide use is not greater than with the previous practise.

Conclusion: Principle (e) confirmed for air quality and likely to be confirmed for soil, water and biodiversity provided that farmers ensure that the use of synthetic fertilizers and pesticides decrease or do not increase, that sustainable irrigation systems (or no irrigation) is in place and farmers take the right soil management measures.

3.6 Evaluation criteria f - no additional demand of land

RED II Article 28(6) point (f) states the following:

> *the need to avoid creating an additional demand for land.*

A defining characteristic of silage crops is the fact that they are harvested before reaching maturity. This makes them suitable for biogas production or animal feed, yet not for human consumption. Silage crops require shorter cultivation periods compared to fully matured crops. This allows them to be cultivated as a second crop while maintaining the yield of the main crops. The Italian Biogasdoneright practice has shown that main crop yields will often slightly reduce as a result of the introduction of sequential cropping, yet this yield reduction is small. **It would be possible to harvest silage crops slightly earlier in order to avoid any reduction in the cultivation period of the main crop.** It can be foreseen that this would be a minimum requirement when implementing sequential cropping for the purpose of inclusion in Annex IX, to ensure that criterion (f) can be met.

Conclusion: Principle (f) likely to be confirmed

4. Conclusion

This paper explores whether **silage crops grown in a sequential cropping system**, as cultivated in Europe, would meet the evaluation criteria for 'advanced feedstock' as included in Article 28(6) of the EU Renewable Energy Directive.

Silage crops are harvested early, meaning they are not fully matured crops. This enables them to be produced in combination with a main crop on the same plot of land without lowering main crop yields. This practice therefore increases overall agricultural output of existing agricultural land. Sequential cropping can be applied in a sustainable way, compliant with EU sustainability criteria for bioenergy feedstocks and not leading to negative environmental impacts under European climatological conditions. **It can be concluded that there is a high degree of certainty that silage crops grown in a sequential cropping system meet the evaluation criteria as set out in Article 28(6), paragraph b of the EU REDII.** It should be highlighted that this memo focuses on sequential cropping as applied for silage crop production as cultivated in Europe (Italy and France) only.