Biomass, Climate Change and the Forest

Key messages:
Biomass is not inherently carbon neutral

Woody biomass should not be considered as a good solution to climate change.

Biomass is an increasingly important issue in the international climate change debate

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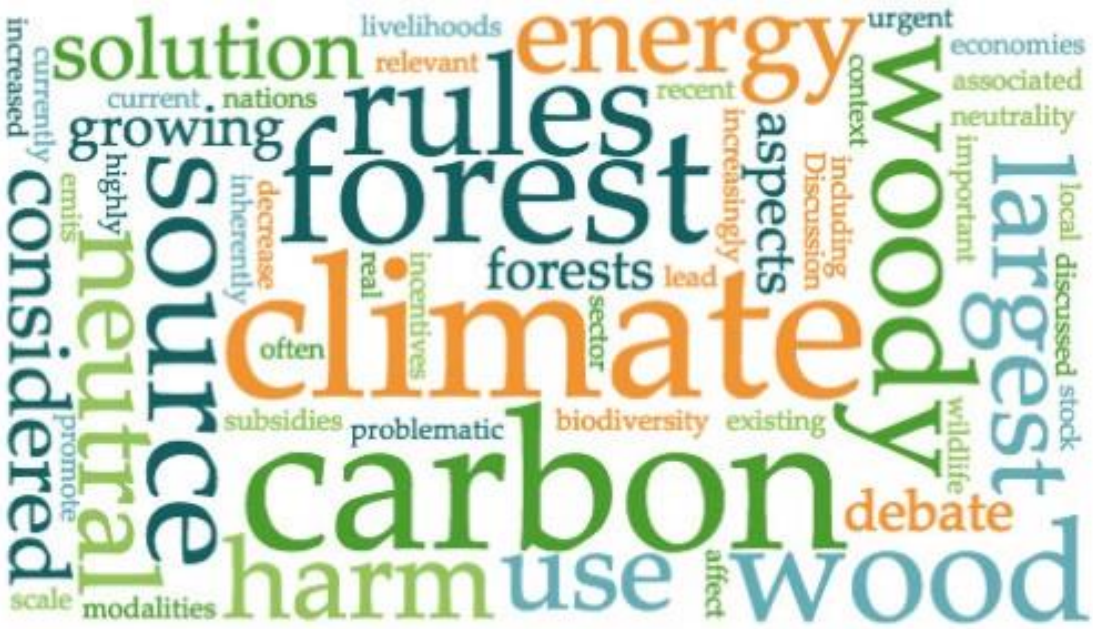

KEY MESSAGES:

Woody biomass is not inherently carbon neutral

The use of woody biomass in energy production is often considered carbon neutral in a climate context. This is first of all because of the accounting practice, where emissions from biomass are included in the land sector and not in the energy sector. Secondly it is because of the assumption that biomass is part of a short carbon cycle, where the CO2 emitted to the atmosphere will be reabsorbed by tree growth. But biomass emits CO2 when it is burned, and current rules do not always ensure accounting of these emissions. Furthermore, the CO2 is not re-absorbed fast enough to avoid contributing to global warming. Assuming an inherent carbon neutrality is therefore problematic.

Woody biomass should not be considered a solution to climate change.

An increased use of wood in large scale power and heating plants risks putting serious pressure on the world's forests. This can lead to a decrease in the global forest carbon stock, and cause harm to forest wildlife, biodiversity, and local livelihoods. Biomass is one of the most land consuming methods for energy production, and energy consuming countries are importing increasing amounts, as they are not able to produce enough themselves. On top of this, burning woody biomass can cause net CO2-emissions, why an extensive use of biomass in energy production should not be considered a good solution to climate change. To use biomass as a national climate solution, all the environmental consequences and emissions have to be accounted for.

Biomass is an increasingly important issue in the international climate change debate

The use of biomass as a CO2 reducing climate solution is growing and so is the pressure on the world's forests. The recent pledge to promote the use of biomass, coming from 19 nations, including some of the world's largest emerging economies, can potentially add to the growing pressure on the forest. Use of biomass is encouraged by existing international accounting rules, and by national policies and subsidies e.g. complete tax exemption in Denmark. New rules and modalities are currently being discussed in both the EU and the UNFCCC, that could affect the incentives for using biomass for energy production. Discussion of the climate aspects of biomass is therefore urgent and highly relevant in the current climate change debate.

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Climate Change, Biomass and the Forest

Jonas Appelt & Gry Bossen

Forests of the World, 2018

Content

Executive Summary

The use of biomass in the energy production is politically considered as carbon neutral why many countries plan to use it to reduce emissions of greenhouse gases in the energy sector. Paradoxically, the expansion in the use of biomass for energy purposes will increase pressure on the world's forests, depleting crucially important forest sinks. At the same time conservation of forests, is one of the best and cheapest solutions to counter the climate crisis. The use of biomass is encouraged by existing international accounting rules, and by national policies and subsidies. Discussion about the emissions from biomass is therefore urgent and highly relevant in the current climate change debate.

The global consumption of wood in the energy sector has increased rapidly in recent years, and forecasts indicates that this development will continue in the foreseeable future. Biomass is by international accounting rules considered carbon neutral in the energy production, which creates great incentives for countries to use biomass to create emissions reductions in their energy sector. Therefore, biomass is continuously being implemented to fulfil countries emissions reductions plans. Recently, 19 countries, including some of the world's largest energy consumers, pledged their commitment to developing the use of biomass as a renewable energy in their energy supply.

However, the use of biomass as renewable energy, has potential negative effects on the climate. The combustion of biomass releases CO2 to the atmosphere - sometimes in bigger quantities than the fossil fuels it has replaced. Re-sequestering of carbon in the continued growth of forests is neither large or fast enough, to avoid the emitted carbon from contributing to the global warming. When biomass is taken out of the forest, a carbon debt is created. If the carbon "payback" time extends to several decades, the burning of biomass does not support the timeframes set out in the Paris Agreement and by IPCC, in order to avoid devastating and irreversible climate changes. Furthermore, the increasing outtake of biomass from the forest, threatens the forest carbon stock. Forests are one of the best and cheapest natural climate mitigation solutions, while also providing crucial non-carbon benefits in terms of biodiversity and livelihood. Classifying biomass as a carbon neutral energy source is therefore problematic.

The world's forests are experiencing an increasing pressure, with multiple and conflicting demands for use. Forest is cut down to satisfy a growing demand for land for agriculture, animal grazing or in order to access natural resources (i.e. mining). Besides the growing pressure to use forest land for other purposes, there is also a growing demand for the natural resources stemming from the forest itself (e.g. timber, paper and biomass). Since there is no indication of reduction in the demand of wood for non-energy purposes, the overall outtake of wood from forests will have to increase, in order to provide biomass for energy. This increase will have to come from either increasing harvest from existing managed forests or from including unmanaged (natural) forests in production, both with devastating consequences for the forests and the climate.

The rising pressure on the forests will negatively affect the biodiversity of both the managed and the natural forests. Leaving little dead organic matter in the forest for organisms to live off, taking out certain types of trees, and promoting monoculture, is all degrading the biodiversity in the forest, resulting in weaker and more vulnerable ecosystems. Forest used primarily for biomass productions will most likely become intensively managed monocultures, with little consideration for biodiversity and the carbon stock in the forest.

Biomass is not inherently carbon neutral. To correctly assess the CO2 impact of biomass, all emissions and sinks associated with harvesting and production of forest-based biomass have to be accounted for. Woody biomass should not be considered as a 'easy fix' solution to climate change, as it emits CO2 to the atmosphere. In addition, the large volumes required can cause depletion of the global forest carbon stocks, which will take years and sometimes many decades to build up again. Biomass used for large scale energy production is an increasingly important and controversial issue in the international climate change debate, where rules and modalities, that could affect the incentives for using biomass, are currently being discussed in both the EU and the UNFCCC.

Introduction

This working paper has been created by Forests of the World in order to highlight the problems with the use of wood in Danish and international energy production, as well as the consequences of increased biomass extraction on the climate and the world's forests. The main goal of the paper is to create an overview of the issues surrounding woody biomass. The aim is to identify the key problems associated with its use in energy production, in order to accommodate further work in the area by the organisation. The scope of the paper is limited to discussing the use of wood as a fuel source in modern, large scale energy production for heat and electricity, in both Denmark and internationally.

The working paper start with describing the current status and development in the global use of solid biomass for energy production in Chapter 1, and the Danish use of wood in the energy production in Chapter 2. Some of the problems associated with the use of woody biomass for the climate and forests are described in Chapter 3. Chapter 4 describes the latest development in biomass policy and the importance of discussing biomass right now is highlighted. Finally, the main conclusions are summarized.

1. Biomass in the global energy production

Over the last couple of decades, biomass has increasingly been used in large heat and power plants as part of large scale energy production. Biomass initially originated from waste from e.g. timber and paper production, but the rapid growth in bioenergy has spurred an expansion in the demand for wood for energy production. Data on the global use of biomass is still sparse, but some information exist on the production and trade of wood chips and pellets, which are the main types of woody biomass used in modern energy production. The global production and consumption of wood pellets has increased considerably over the last decade and estimates are that the use of woody biomass for energy will continue to rise.

Global use of biomass in energy production

The use of biomass, plays an important role in the global energy production. The International Energy Agency (IEA) estimates that biomass accounted for more than 70% of the all renewable energy[1] and for 9.4% of the total energy supply in 2015 (Figure 1)[2]. 90% of the biomass used, came from solid biomass, including wood, charcoal and straws. The large majority of the biomass used globally is in the form of fuelwood and charcoal used in "traditional"[3] energy supply for households in developing countries. It is estimated that close to 70% of all biomass burned globally is in the form of fuelwood[4].

[1] IEA. 2017: *Technology Roadmap - Delivering Sustainable Bioenergy*. Available online: https://www.iea.org/publications/freepublications/publication/technology-roadmap-delivering-sustainable-bioenergy.html

[2] IEA. 2017: *Renewables information: Overview 2017*. Available online: https://www.iea.org/publications/freepublications/publication/renewables-information---2017-edition---overview.html

[3] The use of the categories "traditional" and "modern" in relation to energy supply and biomass energy is often used, but the terms are not well defined. In general, "traditional" refers to fuelwood, charcoal and similar used in open fires or simple ovens in individual households, while "modern" refers to the use of more processed biofuels, including biodiesel, biogas, wood pellets and wood chips in both individual households and central power and heating systems. See also descriptions in IEA. 2017: *Renewables information: Overview 2017*. Available online: https://www.iea.org/publications/freepublications/publication/renewables-information---2017-edition---overview.html; and in World Energy Council. 2016: *World Energy Resources – Bioenergy*. Available online: https://www.worldenergy.org/publications/2016/world-energy-resources-2016/

[4] IEA. 2017: *Renewables information: Overview 2017*; World Energy Council. 2016: *World Energy Resources – Bioenergy*. Available online: https://www.iea.org/publications/freepublications/publication/renewables-information---2017-edition---overview.html

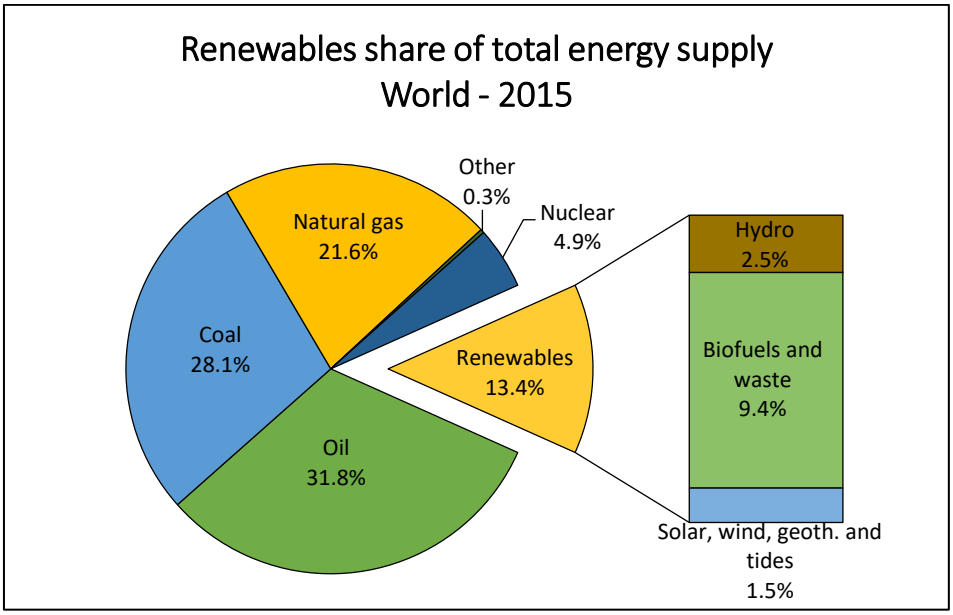

Figure 1: Renewables share of global energy supply, 2015.[5]

In developed countries, the use of "modern" biomass in energy production, e.g. in central power and heating plants, is more prevalent[6]. IEA estimates that 5.2% of primary energy supply in OECD countries was derived from biomass in 2016, with 67% of this coming from solid biomass, including wood pellets, wood chips and straws[7]. Getting precise figures for the energy produced from individual wood-based fuels is difficult, due to differences in national definitions and energy technologies. The most itemized figures can generally be found in the energy statistics from national governments, but these may not be comparable between countries.

This report focus on the use of biomass in "modern" energy production.

Use of biomass in EU

Solid biomass continue to be the largest source of renewable energy within the EU, constituting 12% of the total primary energy production and 45% of the renewable energy production in 2015[8]. As shown in Figure 2, use of solid biomass in EU has increased significantly since 2000, with an expansion in production of 1.6 million Tj or 70%. When that is said, a number of other renewable energy sources (solar, wind and liquid biofuels) have in recent years seen a faster expansion than solid biomass. This means that the relative share of solid biomass out of all renewable energy has fallen from 55% in 2000 to 45% in 2015.

[5] Source of data: IEA. 2017: *Renewables information: Overview 2017*, Figure 1, p. 3. Available online: https://www.iea.org/publications/freepublications/publication/renewables-information---2017-edition---overview.html
[6] World Energy Council. 2016: *World Energy Resources – Bioenergy*. Available online: https://www.worldenergy.org/publications/2016/world-energy-resources-2016/
[7] IEA. 2017: *Renewables information: Overview 2017*. Available online: https://www.iea.org/publications/freepublications/publication/renewables-information---2017-edition---overview.html
[8] Eurostat. 2018: *Simplified energy balances - annual data, nrg_100a*; and Eurostat. 2017: *Supply, transformation and consumption of renewable energies - annual data, nrg_107a*. http://ec.europa.eu/eurostat/data/database

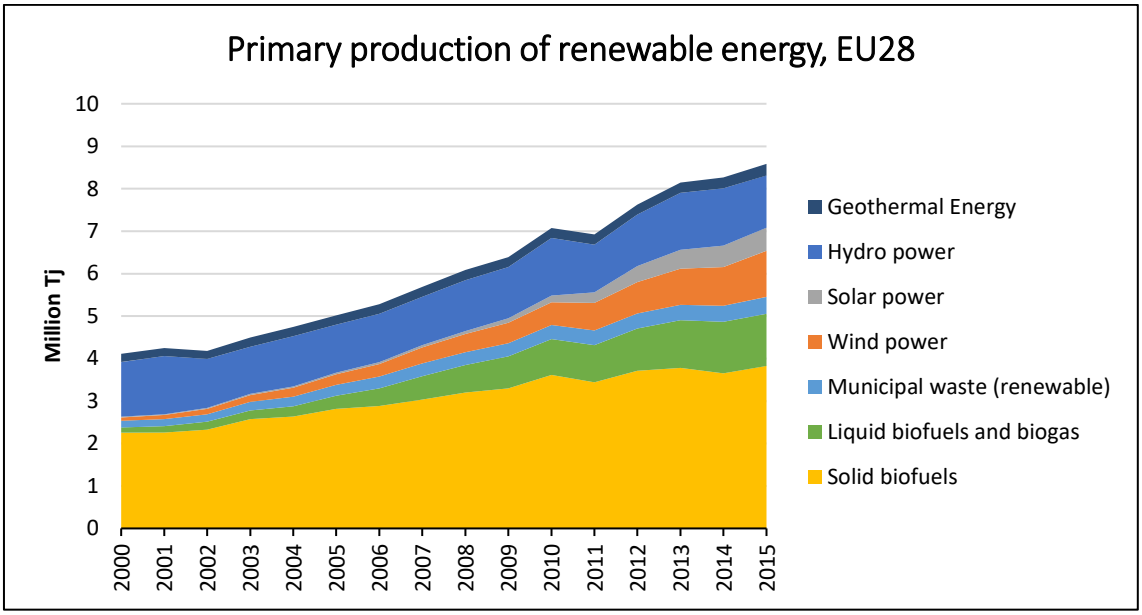

Figure 2: Production of renewable energy divided on sources in EU28, 2000-2015.[9]

More than half of the biomass used for energy and heating in EU comes from various woody biomass, primarily in the form of wood chips and wood pellets[10]. Wood chips, wood pellets and wood industry residues, are all used in modern energy production. Wood chips are used in a number of different products, and it is estimated that less than 10% of chips produced worldwide are used directly in energy production[11]. Wood pellets are on the other hand mostly used in "modern" energy production for heating, in households' pellet stoves and in central heating systems, as well as in large scale power plants[12]. Industry residues and wood chips are generally sourced from areas closer to the place of combustion, so the international trade in woody biomass for energy is captured most distinctly in the global trade figures for wood pellets.

Global trade in wood pellets

Trade in biomass for energy production is primarily in the form liquid biofuels and wood pellets[13]. The global production of wood pellets increased from 18 Mt in 2012 to 29 Mt in 2016, with an increasing amount being exported outside of the producing countries[14]. Figure 3 shows the development in production and export for the ten largest pellet producing countries between 2012 and 2016.

[9] Source of data: Eurostat. 2018: *Supply, transformation and consumption of renewable energies - annual data, nrg_107a*. Available online: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg_107a

[10] European Commission. 2014: *State of play on the sustainability of solid and gaseous biomass used for electricity, heating and cooling in the EU*. Commission Staff Working Document, SWD(2014) 259 final. Available online: https://ec.europa.eu/energy/sites/ener/files/2014_biomass_state_of_play_.pdf

[11] Lamers, P., Marchal, D., Schouwenberg, P., Cocchi, M. & Junginger, M. 2012: *Global Wood Chip Trade for Energy*, IEA Bioenergy. Available online: https://www.researchgate.net/publication/259971159_Global_wood_chip_trade_for_energy

[12] World Energy Council. 2016: *World Energy Resources – Bioenergy*. Available online: https://www.worldenergy.org/publications/2016/world-energy-resources-2016/

[13] Chum, H. et al. 2012: *Bioenergy*, Chapter 2 in IPCC. 2012: *Special Report on Renewable Energy Sources and Climate Change Mitigation*. Available online: http://www.ipcc.ch/report/srren/

[14] Data from Faostat. 2018: *Forestry Production and Trade*. Available online: http://www.fao.org/faostat/en/#data/FO

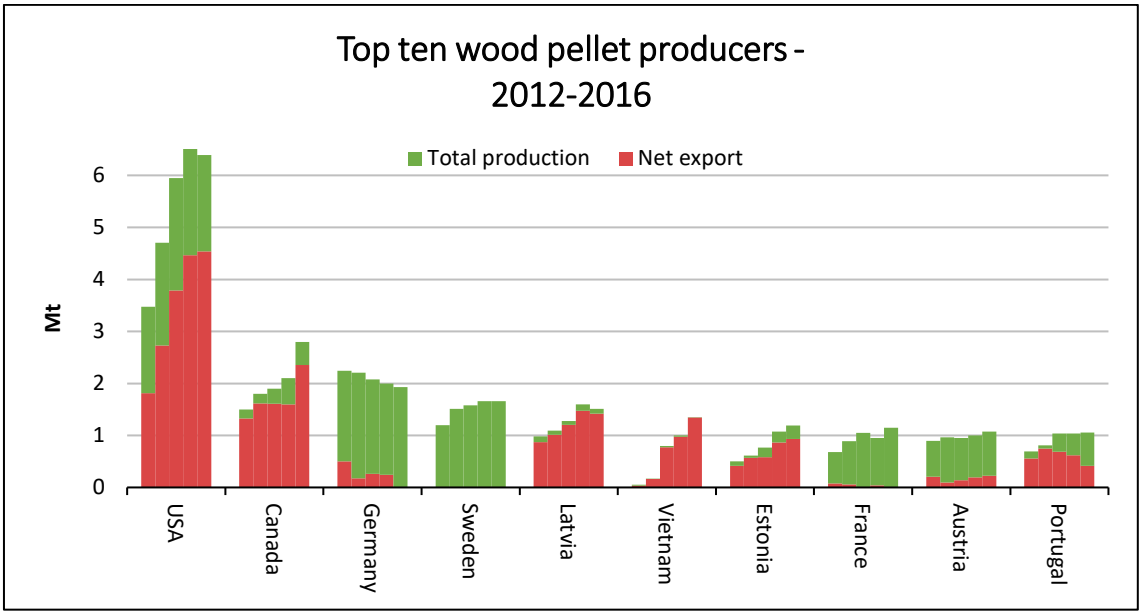

Figure 3: Top ten wood pellet producing countries (in 2016) and the development in production and net-export between 2012 and 2016.[15]

USA is by far the largest producer and exporter of wood pellets, accounting for 22% of global pellet production in 2016. As indicated in Figure 3, a number of countries primarily produce pellets in order to export these (Canada, Latvia, Vietnam, Estonia), while another group of countries (Germany, Sweden, France, Austria) produce primarily for national consumption. Most of the production of wood pellets is found in Europe and North America, with the production in North America increasing significantly in recent years. When that is said, the largest relative growth in production of wood pellets was found in Vietnam, increasing with 2500% from 2012 to 2016.

The primary market for global wood pellets is found in Europe, especially in the EU. In 2016, Europe imported 5.9 Mt wood pellets, and four of the top five importing countries is found within EU (See Table 1). The primary global trade flows consist of export of pellets from North America (USA and Canada) and from Eastern Europe (particular Baltic countries) and Russia, to countries in western Europe[17]. United Kingdom is by far the largest importer of wood pellets in the world, primarily driven by the demand for pellets used in production of electricity[18].

Country	Net import, wood pellets 2016 - Mt
United Kingdom	7.12
Denmark	1.84[16]
Republic of Korea	1.72
Italy	1.65
Belgium	0.78

Table 1: Top five net importing countries of wood pellets in 2016. [19]

A significant amount of pellets are also exported from North America to Asia, especially to Japan (6th largest importing country in 2016). The rapidly expanding production of wood

[15] Source of data: Faostat. 2018: *Forestry Production and Trade*. Available online: http://www.fao.org/faostat/en/#data/FO
[16] It should be noted that this figure for Danish import of wood pellets differ considerably from the figure quoted in Chapter 2. The figure in Table 1 derives from Faostat and is here provided to ensure comparability with the figures for other countries. In the remaining part of this report it is assumed that the figure deriving from Statistics Denmark, quote in Chapter 2, is the more correct estimate of Danish import of wood pellets.
[17] World Energy Council. 2016: *World Energy Resources – Bioenergy*. Available online: https://www.worldenergy.org/publications/2016/world-energy-resources-2016/
[18] Thrän, D., Peetz, D. & Schaubach, K. 2017: *Global Wood Pellet Industry and Trade Study 2017*. IEA Bioenergy Task 40. Available online: http://www.ieabioenergy.com/publications/global-wood-pellet-industry-and-trade-study-2017/
[19] Source of data: Faostat. 2018: *Forestry Production and Trade*. Available online: http://www.fao.org/faostat/en/#data/FO

pellets in Vietnam is almost exclusively exported to Korea, where it covers the majority of the demand[20].

Perspectives in the future use of biomass in energy production

It is projected that solid biomass will continue to play a dominant role in the world's renewable energy supply, with an increased development towards the use of biomass in "modern" heating and power plants[21]. In their 2-degree scenario, IEA projects that bioenergy should account for 17% of the final energy demand in 2060[22]. IEA also calls for a rapid deployment of new biomass technologies. To cover 17% of the energy demand in 2060, IEA's 2-degree scenario predicts that a fivefold increase in the biomass feedstock is needed (from 23 Ej today, to 128 Ej in 2060), which would dramatically increase in the outtake of biomass and the land demanded for biomass production.

In November 2017, during COP23, 19 governments announced an intend for increasing the focus and use of bioenergy (BioFuture Platform). The group included both some of the largest current consumers of wood pellets in the world (UK, Denmark and Sweden) and some of the world's largest emerging economies (China, India and Brazil)[23].

Use of biomass is also seen as a key factor in achieving the renewable energy targets of the EU, where biomass is a prominent feature in the National Renewable Energy Action Plans of a number of member states[24].

The production of wood pellets has increased significantly in recent years, especially in the major exporting countries in North America (USA, Canada), the Baltics (Latvia, Estonia) and in Vietnam. At the same time, some of the large producers in Europe (Sweden, France, Austria) have had only small increases in production, and Germany's production has even been going down (See Figure 3).

The general global tendency is for a substantial increase in the use of woody biomass for "modern" energy production. The demand for woody biomass in energy production systems, seem to be spreading to more countries around the world and there are indications that this will spur the development of biomass production in new countries, that were not previously producing biomass (e.g. Vietnam). The use of woody biomass is thereby contributing to an increasing pressure on the world's forests.

2. Biomass in the Danish energy production

Denmark is one of the most advanced countries when it comes to the energy sector, because of a very well established integrated heat and electricity production and distribution system. Therefore, the use of woody biomass for energy production is by some people considered very effective in Denmark. But Denmark is also consuming the highest amount of wood pellets per capita in the world[25], and is importing 94% of these. As

[20] Thrän, D., Peetz, D. & Schaubach, K. 2017: *Global Wood Pellet Industry and Trade Study 2017*. IEA Bioenergy Task 40. Available online: http://www.ieabioenergy.com/publications/global-wood-pellet-industry-and-trade-study-2017/

[21] World Energy Council. 2016: *World Energy Resources – Bioenergy*. Available online: https://www.worldenergy.org/publications/2016/world-energy-resources-2016/

[22] IEA. 2017: *Technology Roadmap - Delivering Sustainable Bioenergy*. Available online: https://www.iea.org/publications/freepublications/publication/technology-roadmap-delivering-sustainable-bioenergy.html

[23] http://biofutureplatform.org/statements/

[24] European Commission. 2014: *State of play on the sustainability of solid and gaseous biomass used for electricity, heating and cooling in the EU*, Commission Staff Working Document, SWD(2014) 259 final. Available online: https://ec.europa.eu/energy/sites/ener/files/2014_biomass_state_of_play_.pdf

[25] Based on information on pellet production and trade from Faostat. 2018: *Forestry Production and Trade*. Available online: http://www.fao.org/faostat/en/#data/FO

the world looks to Denmark for inspiration, it is highly relevant to understand the Danish situation, and why it might not be sustainable at a larger scale.

Biomass in Denmark

The use of woody biomass in Denmark is favoured because of the integrated heat and electricity production, which makes the burning of woody biomass more effective than in other countries. Danish district heating consists of 405 power plants with different sizes, capacities and ownership statuses, providing 64% of Danish households with district heating[26]. Half of the energy used in the Danish central heating system in 2014 came from renewable sources, primarily from woody biomass such as wood pellets and chips, which made up 26% of the energy sources in 2014, as illustrated in Figure 4.

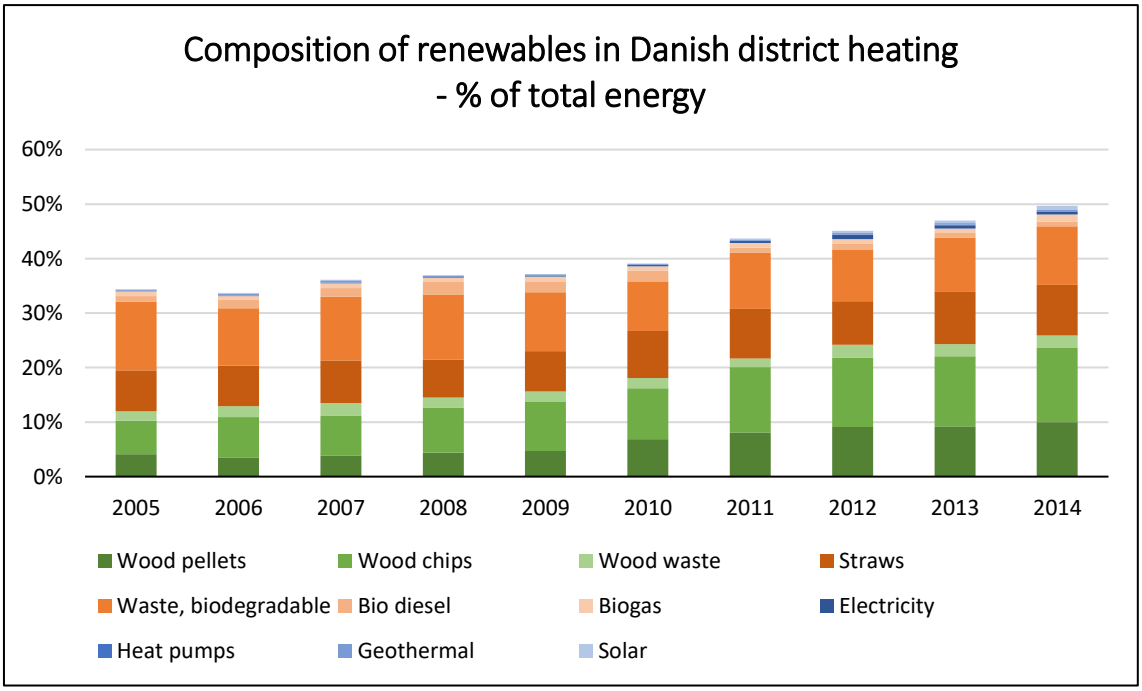

Figure 4: Composition of renewable energy in Danish district heating. Woody biomass fuel sources with green colours, other biomass fuel sources with brown colours and other renewable energy sources with blue colours.[27]

Most of the wood chips are used in the central heat production, whereas almost 40% (approx. 1 Mt)[28] of the pellets were used in private households, industry or in public buildings in 2016. Firewood also represents a significant part of the Danish biomass consumption[29], but this is exclusively used in private homes as an additional source of heating. While the use of firewood has increased in the last couple of years, this is not included in the scope of this report, where the focus is on the use of woody biomass in the central energy system. Woody biomass therefore refers to pellets and chips only in this paper.

[26] Danish District Heating (Dansk Fjernvarme) webpage*: Fjernvarmeinfo.* 2017. Available online: http://www.danskfjernvarme.dk/viden-om/fjernvarmeinfo

[27] Source of data: Danish District Heating Association. 2016: *Halvdelen af fjernvarmen er nu CO2-neutral*, p. 2. Online available: http://www.danskfjernvarme.dk/viden-om/statistik-subsection/aarsstatistik/statistik-2015-2016

[28] EA Energy Analyses. 2017: *Det danske træpillemarked 2016*, Report created for the Danish Energy Agency. Available online: https://ens.dk/sites/ens.dk/files/Statistik/det_danske_traepillemarked_2016.pdf

[29] Danish Energy Agency webpage: https://ens.dk/ansvarsomraader/bioenergi/fast-biomasse

Consumption of Woody Biomass in Danish energy production

The Danish consumption of woody biomass has increased rapidly in the last 15 years, from 0.6 Mt in 2000 to 4.7 Mt in 2016, consisting of 2.2 Mt wood chips and 2.5 Mt wood pellets annually. Where 68% of the wood chips used are produced in Denmark, only 6% of the wood pellets used are being produced nationally (2.4 Mt)[30] [31].

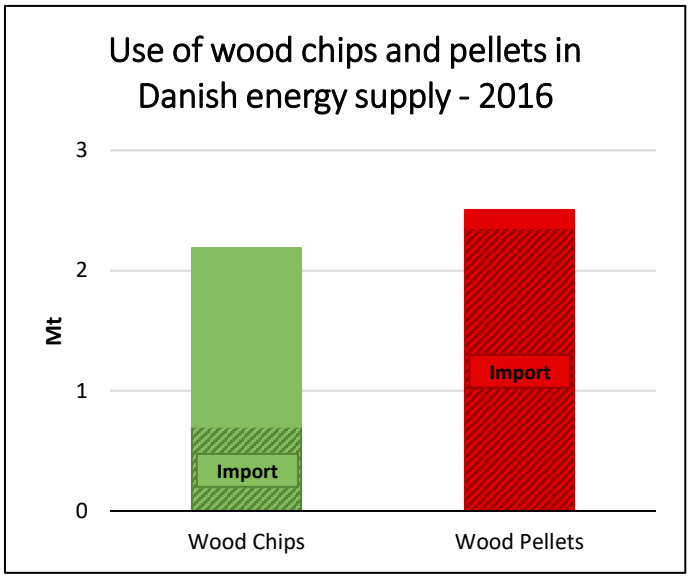

Figure 5: Consumption and import of wood chips and wood pellets to Denmark in 2016.[32]

Denmark has the highest consumption of wood pellets per capita in the world, with each person on average using around 350 kg annually. Compared to this, the consumption in e.g. Sweden is 170 kg annually per capita, and in UK it is 115 kg[33].

Figure 6: Annual consumption of wood pellets in Denmark, Sweden and UK.[34]

[30] Danish Energy Agency. 2017: *Energistatistik 2016*, p. 5. Available online: https://ens.dk/sites/ens.dk/files/Statistik/estat2016.pdf
[31] It should be noted that this figure for Danish import of wood pellets differ considerably from the figure quoted in Chapter 1. The figure of 2.4 Mt quoted here derives from Statistics Denmark, whereas the figure in Chapter 1 is from Faostat.
[32] Based on data from Danish National Statistics (https://www.dst.dk/da/) converted from TJ to T according to a ratio given by the Danish Energy Agency; EA Energy Analyses. 2017: *Det danske træpillemarked 2016*, Report created for the Danish Energy Agency, p. 25 Available online: https://ens.dk/sites/ens.dk/files/Statistik/det_danske_traepillemarked_2016.pdf
[33] Based on information on pellet production and trade from Faostat. 2018: *Forestry Production and Trade*. Available online: http://www.fao.org/faostat/en/#data/FO
[34] Source of data: Faostat. 2018: *Forestry Production and Trade*. Available online: http://www.fao.org/faostat/en/#data/FO

Half of the import of wood pellets in 2016 came from Baltic countries, primarily Latvia (25%) and Estonia (23%). Apart from the 5% imported from USA, all other pellets originated from within Europe.

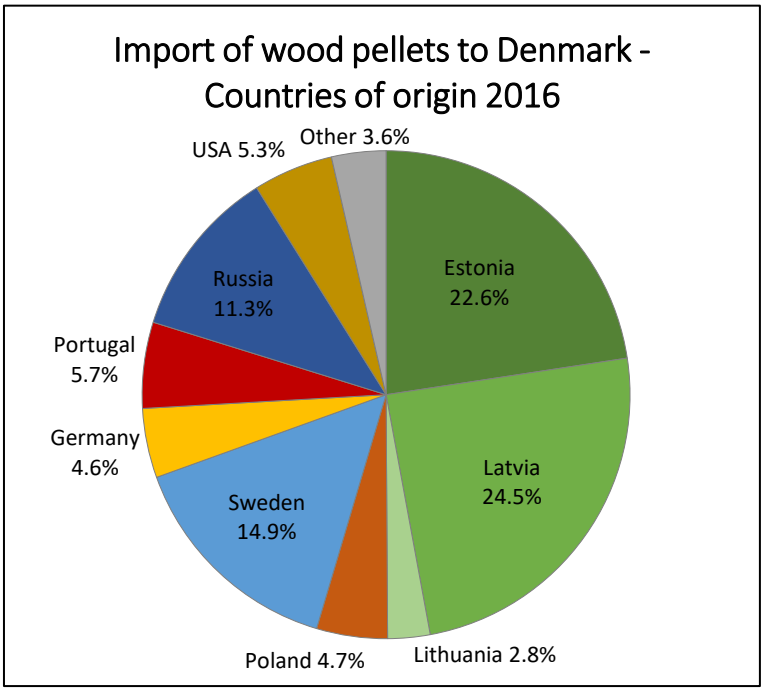

Figure 7: Import of wood pellets to Denmark in 2016 divided on country of origin.[35]

Greenhouse gas emissions from Biomass in Denmark

From 1990 to 2015 the Danish energy sector achieved a 56% decrease in the emissions of greenhouse gas[36]. This reduction was mainly due to the application of renewable energy sources, including biomass and wind power. In these accounts the emissions from biomass burning is not included[37]. But according to Denmark's Green National Account, emissions from burning biomass in the energy sector, have increased from 1.1 Mt in 1990 to 7.4 Mt CO2 in 2015.

Year	1990	1995	2000	2005	2010	2015	2016
MT CO2 from biomass in the energy sector	1.1	1.9	2.5	4.7	7.2	7,4	8.4
MT CO2 from the Energy sector	25.5	30	23.5	20.3	21.1	9.4	10.5

Table 2: CO2 emissions from combustion of biomass in the central energy sector, compared to CO2 emissions from the rest of central Energy Sector (excluding biomass).[38]

[35] EA Energy Analyses. 2017: *Det danske træpillemarked 2016*, Report created for the Danish Energy Agency. Available online: https://ens.dk/sites/ens.dk/files/Statistik/det_danske_traepillemarked_2016.pdf
[36] Statistics Denmark. 2017: *Grønt nationalregnskab for Danmark 2014-2015*. (Green National Accounts), p. 58. Available Online: https://www.dst.dk/Site/Dst/Udgivelser/GetPubFile.aspx?id=27467&sid=gnatdk
[37] Ibid p. 58.
[38] Statistics Denmark. 2018: *Environmental-Economic Accounts (Green National Accounts) - MRU1 Air Emission Accounts by Industry and Type of Emission*. https://www.statistikbanken.dk/statbank5a/SelectVarVal/Define.asp?MainTable=MRU1

In 1990, emissions from biomass combustion amounted to 6% of total CO2 emissions, whereas biomass combustion amounted to almost 17% of the total emissions in 2014[39]. Emissions of greenhouse gases from biomass combustion is of a very significant size compared to other emissions, and almost equal to the official emissions from the energy sector. But the emissions from biomass are not included in the official figures reported to the UNFCCC[40].

Future use of woody biomass

The Danish Energy Agency predicts a doubling in the Danish use of biomass from 57 Pj in 2015 to 98 Pj in 2020[41].

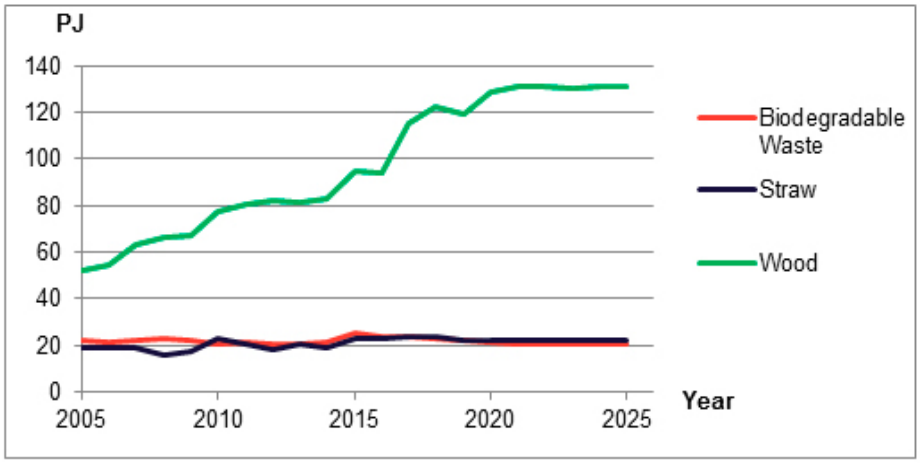

Figure 8: Use of solid biomass in Danish electricity and heat production 2005-2015, and projection to 2025. Pct. energy content.[42]

Modelling of the energy consumption in central heating plants, suggest that the use of woody biomass will increase until at least 2020, where it is projected to stagnate as result of a change in European legislation restricting subsidies[43]. After 2020 there is a lot of uncertainty about the use of biomass. On the one hand, the EU rules ends subsidies to woody biomass in 2019, which could favour the use of coal in future energy scenarios[44]. On the other hand, Denmark has pledged to end the use of coal by 2030. Furthermore, Denmark's biggest energy producer, Ørsted (formerly known as Dong), plans to phase out its use of coal by 2023[45]. If Ørsted is to cover the expected rise in need for electricity consumption after 2020, some old power plants will have to be reinstalled and converted to either biomass or gas. The Danish Energy Agency estimates that,

[39] Statistics Denmark 2017: *Grønt nationalregnskab for Danmark 2014-2015 (Green National Accounts)),* p. 60. Available online: https://www.dst.dk/Site/Dst/Udgivelser/GetPubFile.aspx?id=27467&sid=gnatdk
[40] See chapter 3 on the UNFCCC inventory system.
[41] Danish Energy Agency. 2017: *Basisfremskrivning 2017 (Baseline Projection 2017)*. Available online: https://ens.dk/sites/ens.dk/files/Forsyning/bf2017_hovedpublikation_13_mar_final.pdf
[42] Danish Energy Agency. *Energy and Climate Outlook 2015.* Available Online: https://ens.dk/en/our-responsibilities/bioenergy/solid-biomass
[43] Danish Energy Agency. 2017: *Basisfremskrivning 2017 (Baseline Projection 2017)*.
[44] Ibid. p. 7.
[45] The Danish government has also pledged to phase out coal from the Danish energy supply, but not until 2030. The Danish Government. 2013: *The Danish Climate Policy Plan,* p. 31. Available online: https://ens.dk/sites/ens.dk/files/Analyser/danishclimatepolicyplan_uk.pdf;
Danish Ministry of Energy, Utilities and Climate. 2017: *Regeringen vil sende kullene på pension i 2030.* Available online: http://efkm.dk/aktuelt/nyheder/nyheder-2017/november-2017/kul/

if Ørsted fulfils its pledge to phase out coal, while meeting rising demands, it will lead to a further 19% raise in the use of biomass by 2030, on top of the expected increase between 2005 and 2020[46].

Both the energy industry, the government and environmental organisations in Denmark, agrees that biomass is a temporary solution in the transition for a renewable energy society. But neither the government, nor the industry will specify the transition period and provide a plan for when the use of biomass is to end. If the industry does not transform their power plants into using other energy sources, next time they need renovation, then the Danish biomass consumption will continue to stay at an elevated level well after 2030. Furthermore, it seems that many smaller decentral plants are converting from natural gas to biomass. As shown in figure 9, this is not beneficial as regards CO2 emissions, but the Danish legislation is still favouring this transition.

The European Political context

EU accounts for approximately 12% of the world's greenhouse gas emissions. More than 80 pct. of EU's emissions derives from the production and use of energy, including transportation. The overall climate target set by the EU is to reduce CO2 emissions with 20% by 2020, with 40% by 2030 and with 80-95% by 2050[47]. The 2020 target should be reached by securing 20% renewable energy and 20% increase in energy efficiency[48]. Denmark has, as part of EU's climate target, been assigned to reduce CO2 emissions with 20% from 2005 to 2020. In addition, 30% of the Danish energy production has to come from renewable sources in 2020[49].

European Legislations

The energy sector is subject to extensive regulation in the EU. EU legislation currently ensures subsidies for biomass. But according to European legislation there will be no more subsidies for biomass plants constructed after 2019[50]. Furthermore, a revision of the Renewable Energy Directive (REDII) can cause the Danish industry's own sustainability criteria[51] to be dismissed[52]. This can lead to either stricter or more lax sustainability criteria for the produced and imported biomass. Either way, this new legislation will apply to all biomass being used or produced in EU member states.

The Danish Political context for biomass

The former Danish government had set a target of reaching 40% reduction in greenhouse gases in 2020 (compared to the 1990 level)[53], as laid out in the Danish Climate Plan from 2013. According to this, Denmark was supposed to end the use of coal by 2030, and to cover 100% of the electricity and heat production with renewable energy by 2035[54]. Unfortunately, the current government has abandoned this target, only to set

[46] The Danish Government. 2013: *The Danish Climate Policy Plan,* p. 31. Available online: https://ens.dk/sites/ens.dk/files/Analyser/danishclimatepolicyplan_uk.pdf
[47] The European Commission. 2018: *EU Climate Action*. Available Online: https://ec.europa.eu/clima/citizens/eu_en
[48] The Danish Parliament webpage on European politics and climate plans. 2018. Available Online: http://www.eu.dk/da/fakta-om-eu/politikker/klimapolitik
[49] Ibid.
[50] European Commission. 2014: *Guidelines for State Aid for Environmental Protection and Energy 2014-2020,* Official Journal of the European Union. Available Online: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014XC0628(01)
[51] The Industry Agreement (*Brancheaftalen*) was created in 2016 by Danish Energy and the Danish District Heating Association. Available Online: https://ens.dk/sites/ens.dk/files/Bioenergi/141204brancheaftale_biomasse_de_dffpdf.pdf
[52] Information from personal correspondance in meeting with Danish Energy (*industry organisation*).
[53] The Danish Parliament webpage on European politics and climate plans. 2018. Available Online: http://www.eu.dk/da/fakta-om-eu/politikker/klimapolitik
[54] Climate, Energy and Supply Ministerium. 2013. *Government climate plan, Towards one society without greenhouse gases.* p. 37. Available online: https://ens.dk/sites/ens.dk/files/Analyser/regeringens_klimaplan.pdf

out a less ambitious target of at least 50% renewable energy in 2030 and a target of Denmark being a low-emissions and fossil free society by 2050[55]. The Danish Energy Agreement from 2012, sets out targets and measures for the development of the Danish energy system until 2020. The Energy Agreement was made in 2012 when the national strategy aimed for 100% renewable energy in the whole energy sector in 2050[56]. The Energy Agreement and its forescribed strategy to reach 100% renewable energy by promoting the use of renewable energy - especially wind and biomass, is valid until 2020, but is set to be renegotiated in 2018[57]. In this agreement the use of biomass is subsidised, instead of being taxed, like fossil fuels are. The use of electricity from biomass is also exempted from energy and CO2 taxes, which are imposed on electricity from fossil fuels[58]. The current negotiations on the new Energy Agreement, do not seem to favour biomass any less[59]. So far there is no indication of changes in the lack of taxes on biomass in the near future.

The Danish Legislations

The rules regulating the Danish central heating sector also favours the use of biomass. All new plants (or renovation of old plants) must be approved according to the current law. The *Central Heating supply law* mandates, that the municipal boards[60] approve the construction of new or renovated plants according to a set of rules specified by the climate minister[61] or the regulation provided in the *Executive Order on approval of projects for collective heat supply plants*[62]. According to the executive order, the approval of a new construction can only happen after an individual assessment showing that the proposed plant will be the most socio-economic[63] beneficial project[64] [65]. As the (socio-economic) cheapest source of energy in Denmark right now is biomass - because of the provided incentives and lack of taxation - this is the main energy source on most new or reconstructed power plants. It is reasonable to assume that it will continue to be so, until either the rules for the construction of new plants or the subsidies for biomass are changed.

The use of woody biomass in Denmark is favoured by regulations, set by both the EU and the Danish government. The Danish energy plans and projections of energy production indicate that the use of woody biomass will keep rising until at least 2020. If neither the Danish legislation or the EU mandated rules on subsidies are changed, they will continue to favour biomass in the future as well. While this lowers the

[55] Altinget. 2017: Konservativt Nederlag, regeringen dropper klimamål for 2030. Online Available: https://www.altinget.dk/artikel/konservativt-nederlag-regeringen-dropper-klimamaal-for-2030

[56] Climate, Energy and Supply Ministerium. 2013. *Government climate plan, Towards one society without greenhouse gases*. Available online: https://ens.dk/sites/ens.dk/files/Analyser/regeringens_klimaplan.pdf;
Danish Energy Agency. Webpage on the *Energy Agreement 22 March 2012.* Available online: https://ens.dk/ansvarsomraader/energi-klimapolitik/politiske-aftaler-paa-energiomraadet/energiaftalen-22-marts-2012

[57]Energy Agency, 2012. Notat; Samlede effekter for perioden 2012-2020 som følge af Energiaftalen af 22. marts 2012. Online Available: https://ens.dk/sites/ens.dk/files/EnergiKlimapolitik/samlede_effekter_energiaftalen_030412.pdf

[58] Danish Energy Agency. 2018: *Fast Biomasse*, Webpage. Available Online: https://ens.dk/ansvarsomraader/bioenergi/fast-biomasse;
Energistyrelsen (Danish Energy Agency). 2017. *Oversigt over støtteregler mv. for elproduktion baseret på vedvarende energi og anden miljøvenlig elproduktion,* Notat. Available Online: https://ens.dk/ansvarsomraader/bioenergi/fast-biomasse

[59] Ingeniøren. 2018. Energidebat: Skal biomasse fortsætte i hovedrollen? Available online: https://ing.dk/artikel/energidebat-skal-biomasse-fortsaette-hovedrollen-211163

[60] "Kommunalbestyrelse" in Danish.

[61] Lov om varmeforsyning (Law on heating supply) §2, point 4 par. 5. Available online: https://www.retsinformation.dk/Forms/R0710.aspx?id=190081

[62] Bekendtgørelse om godkendelse af projekter for kollektive varmeforsyningsanlæg (Executive Order on approval of projects for collective heat supply plants). Available online: https://www.retsinformation.dk/Forms/R0710.aspx?id=183229

[63] "Socio-economic most beneficial" is calculated according to the guidance note: *Guidance in socioeconomic analyzes in the field of energy.* This contains a cost-benefit analysis that includes the economic costs and risks, the social benefits such as jobs and the potential environmental benefits such as CO2 savings. Source: Danish Energy Agency. 2005. *Guidance in socioeconomic analyzes in the field of energy.* Available online: https://ens.dk/sites/ens.dk/files/Analyser/vejledning_2005-rev2007.pdf

[64] The socio-economic analysis is decided by the Danish Energy Agency according to §2 point 9 in Executive Order on approval of projects for collective heat supply plants; https://www.retsinformation.dk/Forms/R0710.aspx?id=183229

[65] Executive Order on approval of projects for collective heat supply plants §26, par. 2. Available Online: https://www.retsinformation.dk/Forms/R0710.aspx?id=183229

officially reported CO2 emissions from the energy sector, the actual CO2 emissions from biomass will increase with the use of woody biomass. Furthermore, the Danish use of biomass, is relying intensely on a high level of import, without consideration for the sustainability if the Danish energy system is copied at a global level.

3. The problems with woody biomass

Biomass is classified as renewable fuel when used in energy production and is considered one of the most important solutions to the climate crisis. Biomass is continuously being implemented and pursued in climate strategies in countries around the world. The global consumption of wood in the energy sector has increased rapidly in recent years, and the development indicates that this will continue in the foreseeable future. However, the use of biomass for energy should be considered carefully, as there are problems associated with both the existing forest carbon stocks, when increasing extraction of wood from forests and with the accounting of CO2 from this. In this chapter we will look into why biomass should not be considered carbon neutral, how it is accounted for in UNFCCC and what consequences the extensive extraction of biomass has for the world's forests.

3.1 Why woody biomass is not carbon neutral

The climate effects of using biomass for energy production has been discussed considerably in the context of the international climate debate and was addressed specifically by the IPCC in both the 2012 Special Report on Renewable Energy Sources and Climate Change Mitigation[66], as well as in the chapter on land mitigation in the Fifth Assessment Report[67].

The inherent assumption that using biomass in energy production is CO2 neutral, or even that it is better than using fossil fuel, has been questioned by the scientific community[68], NGOs[69], national governments[70], and the IPCC[71].In the following section, some of the problems in assuming that biomass is carbon neutral is laid out.

Actual CO2 emissions from burning biomass

Burning of wood for energy production creates emissions of greenhouse gases. When burned, the direct emissions from combustion of woody biomass are generally higher than for fossil fuels. This is due to the

[66] Chum, H. et al. 2012: *Bioenergy*, Chapter 2 in IPCC. 2012: *Special Report on Renewable Energy Sources and Climate Change Mitigation*. Available online: http://www.ipcc.ch/report/srren/

[67] Smith, P. et al. 2014: *Agriculture, Forestry and other Land Uses (AFOLU)*, Chapter 11 in IPCC. 2014: *Mitigation of Climate Change - Working Group III Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Available online: http://www.ipcc.ch/report/ar5/wg3/

[68] Haberl, H. et al. 2012: *Correcting a fundamental error in greenhouse gas accounting related to bioenergy*, Energy Policy 45(2012)18–23. Available online: https://www.sciencedirect.com/science/article/pii/S0301421512001681;
Agostini, A., Giuntoli, J. & Boulamanti, A. 2014: *Carbon accounting for forest bioenergy - Conclusions and recommendations from a critical literature review*, European Commission - Joint Research Center, Report EUR 25354 EN. Available online: https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/carbon-accounting-forest-bioenergy-conclusions-and-recommendations-critical-literature

[69] Climate Action Network. 2016: *NGO Position on the Post-2020 LULUCF Regulation*. Available online: www.caneurope.org/docman/land-based-emissions/3023-can-europe-lulucf-position-dec-2016/file; Climate, Land, Ambition and Rights Alliance. 2017: *Climate Action in the Land Sector: Treading carefully*. Available online: http://www.fern.org/treadingcarefully

[70] Danish Energy Agency. 2014: *Analyse af bioenergi i Danmark*. Available online: https://ens.dk/ansvarsomraader/bioenergi/bioenergi-i-danmark/analyse-af-bioenergi-i-danmark

[71] IPCC Task Force on National Greenhouse Gas Inventories. 2018: Frequently Asked Questions. Available Online: http://www.ipcc-nggip.iges.or.jp/faq/faq.html

conversion efficiency of wood being lower than that of fossil fuels, producing less energy per kg CO2 emission[72].

The conversion efficiency for wood varies considerably based on the technology and type of wood used, but general figures can be found in the guidelines for National Greenhouse Gas Inventories from IPCC. Here the default emission levels are set to 112 t CO2/Tj when using wood as a fuel source in the energy sector. This is higher than the suggested emission level for coal, which range between 98.3 - 101 t CO2/Tj, and double the emission level suggested for natural gas, at 56.1 t CO2/Tj[73] (illustrated in Figure 9).

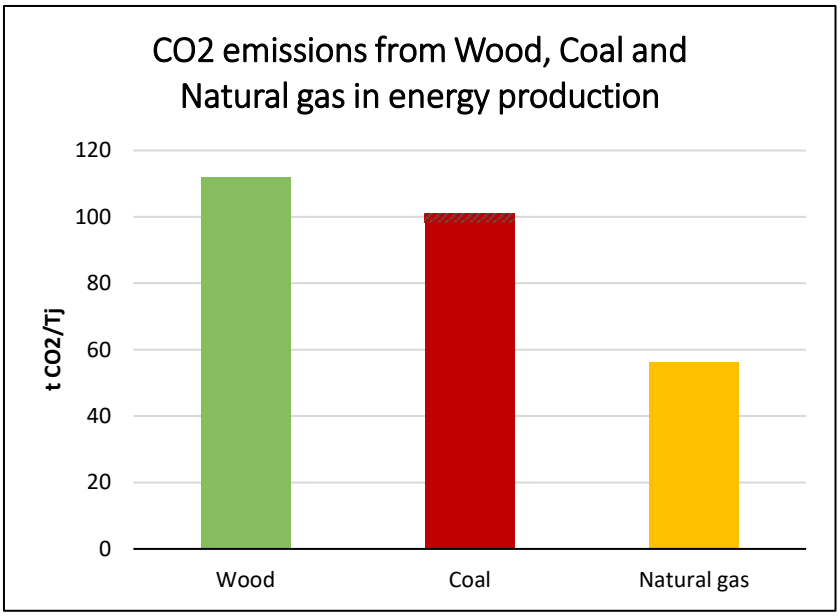

Figure 9: CO2 emissions from energy production, based on different fuel sources. Standard figures from IPCC[74]. Emission factors for coal range between 98.3 to 101 tCO2/Tj, depending on type. It should be noted, that the figure is based on the standards from IPCC, but there is a lot variation in the emissions from wood, depending on species and type of technology.

Carbon debt and additional debt

It is well established that when you harvest woody biomass for energy production, a carbon debt is created[75]. The carbon debt is the amount of stored carbon that has been taken out of the forest. The idea is that the carbon debt will be paid back, when the forest grows and resequesters the same amount of carbon. The time

[72] Agostini, A., Giuntoli, J. & Boulamanti, A. 2014: *Carbon accounting for forest bioenergy - Conclusions and recommendations from a critical literature review*, European Commission - Joint Research Center, Report EUR 25354 EN. Available online: https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/carbon-accounting-forest-bioenergy-conclusions-and-recommendations-critical-literature

[73] IPCC, 2006: *Guidelines for National Greenhouse Gas Inventories, Vol. 2 (Energy)*. Cited from Brack, D. 2017: *Woody Biomass for Power and Heat Impacts on the Global Climate*, Chatham House, Table 1, p. 14. Available online: https://www.chathamhouse.org/publication/woody-biomass-power-and-heat-impacts-global-climate

[74] Ibid. Table 1, p. 14.

[75] Ter-Mikaelian, M. T., Colombo, S. J., and Chen, J. 2015. *The Burning Question: Does Forest Bioenergy Reduce Carbon Emissions? A Review of Common Misconceptions about Forest Carbon Accounting,* Journal of Forestry, January 2015. Available online: https://www.researchgate.net/publication/271224456_The_Burning_Question_Does_Forest_Bioenergy_Reduce_Carbon_Emissions_A_Review_of_Common_Misconceptions_about_Forest_Carbon_Accounting

Lamers, P. & Jungninger, M., 2013. *The 'debt' is in the detail: A synthesis of recent temporal forest carbon analyses on woody biomass for energy,* Biofuels, Bioprod. Bioref. 7:373–385 (2013). Available online: https://www.researchgate.net/publication/259576449_The_%27debt%27_is_in_the_detail_A_synthesis_of_recent_temporal_forest_carbon_analyses_on_woody_biomass_for_energy

it takes to reach the pre-harvest carbon level is the 'payback' or 'repayment time[76]. According to some, biomass is carbon neutral because the carbon debt will be paid back over time. But this approach neglects to account for the potential continued sequestration in the trees, had they not been cut down. The original trees would have continued to increase the forest carbon stock in the same timespan as the new tree uses to reach the pre-harvest carbon level. The difference between the new tree at the pre-harvested carbon level and the additional potential of the original tree, had it still been there, can be characterized as an additional carbon debt, that will never be repaid or reached in a managed forest[77]. Therefore, biomass from logging of whole stems in managed forests is not carbon neutral, even if the forest regrows.

Forests continue to sequester and store carbon

Often models and calculations for carbon payback time assume that the sequestration rate of a forest will stagnate after a certain time. This is however not the case. Various studies show that most forests continue to sequester and store carbon[78]. Even in old forests, carbon continue to be stored both in the soil organic matter[79], which is dependent on dead organic material in the forest, and in the old tree trunks. One study even showed that the rate of tree carbon accumulation increases with tree size and therefore older trees sequester more carbon per day than younger and smaller trees[80]. At the same time, when dead trees decompose, they slowly release some of the stored carbon to become soil organic carbon, while emitting the rest to the atmosphere. But the decomposition of old trees takes decades, and compared to the burning of woody biomass, delays the CO2 emissions significantly. This is crucial in the understanding of the significance of extracting biomass from the forest. It changes the premise for the before mentioned models, where carbon sequestration stagnates and therefore makes it possible for the forest to regrow to the same size and pay back all carbon debts. Extensive management of a forest will negatively affect its ability to sequester and store carbon.

Timeframe

In a 2014 report on biomass use in energy production, the Joint Research Centre of the European Commission concluded that: "...the assumption of biogenic carbon neutrality is not valid under policy relevant time horizons … if carbon stock changes in the forest are not accounted for"[81]. Attempts to estimate carbon payback periods suggest that these vary substantially, from less than 20 years to many decades and in some cases even centuries[82]. It has been argued[83] that the length of the carbon payback period does not matter as long as all emissions are eventually absorbed. This derives from the thinking that forest biomass is part of a

[76] Ibid.

[77] This is especially the case when the assumption is that 1) a forest will continue to sequester and store carbon, when not disturbed; and 2) the alternative to harvesting biomass would be to leave more trees in the forest.

[78] Agostini, A., Giuntoli, J. & Boulamanti, A. 2014: *Carbon accounting for forest bioenergy - Conclusions and recommendations from a critical literature review*, European Commission - Joint Research Center, Report EUR 25354 EN. Available online: https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/carbon-accounting-forest-bioenergy-conclusions-and-recommendations-critical-literature;
Matthews, R. et al. 2015: *Review of literature on biogenic carbon and life cycle assessment of forest bioenergy*, Forest Research. Available online: https://ec.europa.eu/energy/sites/ener/files/documents/2014_05_review_of_literature_on_biogenic_carbon_report.pdf;
Framstad, E., Wit, H., Mäkipää, R., Larjavaara, M., Vesterdal, L. & Karltun, E. 2013: *Biodiversity, carbon storage and dynamics of old northern forests,* Norden, Nordic Council of Ministers, p. 90. Available online: http://www.diva-portal.org/smash/get/diva2:702580/FULLTEXT01.pdf

[79] Crowther, T. H.et al. 2015: *Mapping tree density at a global scale,* Nature, vol. 525, pp. 201–205, doi: 10.1038/nature14967

[80] Stephenson, N. L., et. al. 2014: *Rate of tree carbon accumulation increases continuously with tree size,* Nature vol. 507, pp. 90–93, doi:10.1038/nature12914

[81] Agostini, A., Giuntoli, J. & Boulamanti, A. 2014: *Carbon accounting for forest bioenergy - Conclusions and recommendations from a critical literature review*, European Commission - Joint Research Center, Report EUR 25354 EN, p. 77.

[82] Brack, D. 2017: *Woody Biomass for Power and Heat Impacts on the Global Climate*, Chatham House. Available online: https://www.chathamhouse.org/publication/woody-biomass-power-and-heat-impacts-global-climate

[83] Helin, T. Et al. 2013. *Approaches for inclusion of forest carbon cycle in life cycle assessment – a review,* Global Change Biology Bioenergy (2013) 5, 475–486. Available online: http://onlinelibrary.wiley.com/doi/10.1111/gcbb.12016/full

green carbon cycle, which is a closed system, where there is always this certain amount of carbon in flux. However, ignoring emissions from biomass, disregards the target set forth by the 2015 Paris Agreement of keeping global warming well below 2 degrees, aiming at 1.5 degrees. To limit global warming to within a 2-degree level, greenhouse gas emissions are required to peak before 2020 and be reduced to zero by 2080[84]. Therefore, burning biomass and releasing CO2 that probably will not be reabsorbed by trees for the next 50-100 years, is not compatible with the Paris Agreement timeframe. Assuming carbon neutrality due to the green carbon cycle, furthermore ignores the potential heating impact of release of emissions, as described below.

Heating potential from biomass emissions

Biomass emits a significant amount of CO2 at the time of combustion (a "pulse" of emissions), which has an instant critical heating potential. As described above, the idea that biomass can be considered carbon neutral derives from the thinking that any emissions will be recovered by growth in the producing forests. But this assumption neglects to account for the heating potential during the time it takes for the trees to re-sequester the carbon (carbon payback time). The actual time it will take to recover the additional emissions vary significantly, depending on which parts of the trees are burned (e.g. using of whole stems or only using residues from wood and paper industry), the forest type and other physical and management factors. The payback time can therefore vary from less than a decade to several centuries[85]. It is important to note, that the "pulse" of emissions cause an increase in CO2 levels in the atmosphere that impacts global warming in the intermediate period. In other words, use of biomass increases CO2 emissions, and the released CO2 will add to global warming while it is in the atmosphere. The effect of these "pulse" emissions is particularly large when biomass with slow regrowth is burned. For trees with growth periods of 80-100 years, the warming created in the first 20 years after combustion is almost not mitigated by tree regrowth[86]. As the next 30 years (2020-2050) are crucial for the global warming tipping point, the heating potential of these "pulse" emissions is critical and assuming carbon neutrality in burning biomass might have considerable negative consequences.

Demands for the future

One of the main factors associated with the use of biomass in energy production is the impact this has on both current and future land use. Not only does production of biomass for energy require large areas of land (discussed further in Section 3.2), but any calculation of CO2 emissions associated with this is also dependent on the future management of these areas. The neutrality of the emissions created at the time of burning depends on maintenance of the overall forest carbon stock in the future. Emissions are theoretically offset *only* if the carbon stock is maintained at the same level, which depend on the current and future management practices being similar to historic forest management[87].

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[84] IPCC. 2014: *Climate Change 2014 Synthesis Report Summary for Policymakers,* p. 21, Online available; https://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_SPM.pdf

[85] Agostini, A., Giuntoli, J. & Boulamanti, A. 2014: *Carbon accounting for forest bioenergy - Conclusions and recommendations from a critical literature review*, European Commission - Joint Research Center, Report EUR 25354 EN. Available online: https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/carbon-accounting-forest-bioenergy-conclusions-and-recommendations-critical-literature.

[86] The Global Warming Potential (GWP) in the first 20 years is 0.94-0.96 for trees with rotation times of 80-100 years. Agostini, A., Giuntoli, J. & Boulamanti, A. 2014: *Carbon accounting for forest bioenergy - Conclusions and recommendations from a critical literature review*, European Commission - Joint Research Center, Report EUR 25354 EN, p. 45. Available online: https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/carbon-accounting-forest-bioenergy-conclusions-and-recommendations-critical-literature.

[87] Brack, D. 2017: *Woody Biomass for Power and Heat Impacts on the Global Climate*, Chatham House. Available online: https://www.chathamhouse.org/publication/woody-biomass-power-and-heat-impacts-global-climate

With the continued increase in consumption of biomass for energy production, it is reasonable to assume that forest management will be impacted, either by increased outtake from already managed forest or by taking lightly or unmanaged, primary forest into use. Both of these developments will reduce the forest carbon level. It is estimated that carbon sink effect from the standing European forests will fall with approximately 35% between 2010 and 2030, due to changes in forest management, with the most significant impact being increased outtake of biomass for energy production[88].

3.2 How emissions from woody biomass are accounted for in UNFCCC

A major reason for the assumption that burning of biomass in the energy sector is carbon neutral, originates from the methods used for reporting and accounting of greenhouse gases, e.g. in national accounts or in reporting to the UNFCCC. Carbon stocks in forests are accounted under the Land Use Land Use Change and Forestry (LULUCF) sector in UNFCCC reporting. The accounting rules used for reporting under the LULUCF sector were developed by the IPCC[89], when the use of biomass in modern energy production was considerably less widespread than today.

Accounting rules under the UNFCCC

The method used for reporting of National Greenhouse Gas Inventories to the UNFCCC is based on guidelines developed by the IPCC, where emissions are divided into four different sectors: Energy production, industry, waste, and land use. Accounting of emissions from the land sector (LULUCF) is treated somewhat different than emissions deriving from the energy, waste and industry sectors. While emissions from energy production and industry are calculated based on the amount of actual greenhouse gases released into the atmosphere, emissions from the land sector are based on changes in the carbon stock in an area[90]. In these rules, biomass is part of the land sector and the emissions are not counted in the energy sector.

Emissions resulting from increased wood harvest from forests and/or deforestation is therefore only captured by changes in the overall forest carbon stock. When biomass is removed from the forest, it should in theory be counted as CO2 emissions in the forest[91]. Burning of biomass is therefore deliberately treated as being carbon neutral in the energy and industry sectors. This accounting method was introduced by the IPCC to eliminate the risk of double counting[92], but the assumption was *never* that burning of biomass actually is carbon neutral[93]. Therefore, proper accounting of the emissions coming from the use of biomass in the energy sector is dependent on land sector accounting being complete. For imported biomass, emissions should be included in the reporting of the exporting country.

[88] European Commission. 2016: *EU Reference Scenario 2016 - Energy, transport and GHG emissions trends to 2050*. Luxembourg. Available online: https://ec.europa.eu/energy/sites/ener/files/documents/ref2016_report_final-web.pdf

[89] IPCC. 2003: *Good Practice Guidance for Land Use, Land-Use Change and Forestry*. Available online: http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf.html;
IPCC. 2006: *Guidelines for National Greenhouse Gas Inventories - Volume 4 Agriculture, Forestry and Other Land Use*. Available online: https://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html

[90] Iversen, P., Lee, D. & Rocha, M. 2014: Understanding Land Use in the UNFCCC. Available online: http://ghginstitute.org/wp-content/uploads/2015/04/Understanding_Land_Use_in_the_UNFCCC.pdf

[91] As decided by the UNFCCC in the Annex to Decision 2/CMP.7 - Definitions, modalities, rules and guidelines relating to land use, land-use change and forestry activities under the Kyoto Protocol (Available online: http://unfccc.int/resource/docs/2011/cmp7/eng/10a01.pdf)

[92] IPCC Task Force on National Greenhouse Gas Inventories. 2018: Frequently Asked Questions. http://www.ipcc-nggip.iges.or.jp/faq/faq.html

[93] Agostini, A., Giuntoli, J. & Boulamanti, A. 2014: *Carbon accounting for forest bioenergy - Conclusions and recommendations from a critical literature review*, European Commission - Joint Research Center, Report EUR 25354 EN. Available online: https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/carbon-accounting-forest-bioenergy-conclusions-and-recommendations-critical-literature.

It should be noted that accounting of bioenergy is abnormal, in that biomass is the only energy fuel where emissions are not counted at the point of combustion, but instead included in the emissions at the point of production. It is important to note that the UNFCCC guidelines are *not* saying that the burning of biomass for energy is carbon neutral, but only that it should be accounted in the land sector.

Land sector accounting

Since the emissions from burning biomass is not counted in the energy sector, it is important that they are properly accounted for in the land sector. Historically the UNFCCC has differentiated in the reporting demands for Annex 1 and non-Annex 1 countries. Where Annex 1 countries have been obliged to report on the CO2 emissions from their land sector, this has been optional for the non-Annex 1 countries. Furthermore, the Kyoto Protocol only sets a reduction target for Annex 1 parties in the first period and raised this with a separate reporting on forest management in the second period. The Kyoto Protocol will be replaced by the Paris Agreement in 2020. The Paris Agreement does not hold the same division of parties in Annex 1 and non-Annex 1 countries, and negotiation on the exact accounting guidelines and reporting requirements under the Paris Agreement is still ongoing. It is not yet clear if or how the accounting rules from the Kyoto Protocol, will be adopted by the Paris Agreement. It is therefore essential to understand what the significant flaws of the Kyoto Protocol accounting rules are.

First of all, the Kyoto Protocol only obliged Annex 1 parties to report on forest management. As such both non-Annex 1 countries and the countries that have not signed the Kyoto Protocol, have not had to report on forest management. This means that when the biomass has been produced in non-Annex 1 parties or countries outside the Kyoto protocol, there is no guarantee that these countries have had to account for any decrease in their forest carbon stock. This can have resulted in the emissions from the biomass combustion not being counted for by any country. This seriously hampers with the notion of biomass being carbon neutral in the country of combustion. It is essential that the Paris Agreement guidelines ensure that loss of forest carbon stocks are included in the reporting requirements for all countries.

Another crucial flaw in the LULUCF accounting rules has been the baseline by which forest carbon stocks are measured[94]. Calculating forest carbon stocks from a politically projected baseline, can risk giving way for a lot of deforestation not accounted for, as long as this was part of a planned deforestation, thereby hiding actual net-emissions of CO2 to the atmosphere. This is another reason why biomass cannot be considered as inherently carbon neutral, as it leaves the emissions from the cut and burn of biomass counted nowhere. Correct accounting of emissions from woody biomass is therefore first of all dependent on how well exporting countries account for changes in their forest carbon stocks.

It is important to note, that the EU has recently negotiated their own LULUCF rules, and these may set precedent for other countries and maybe even for the UNFCCC.

3.3 Why increased pressure on the world's forests is critical

The world's forests are experiencing an increasing pressure, with multiple and conflicting demands for use[95]. Forest is cut down for a multitude of purposes, including agricultural expansion, animal grazing or in order to access natural resources (i.e. mining). Besides the interest in alternative use for the land where forests grow,

[94] IPCC. 2013: *Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol*. Available online: http://www.ipcc-nggip.iges.or.jp/public/kpsg/index.html

[95] FAO. 2016: *Global Forest Resource Assessment 2015 - How are the world's forests changing?* Available online: www.fao.org/3/a-i4793e.pdf

there is also an increasing demand for the resources stemming from the forest itself. This could be plant fibres to substitute consumption of plastic or nuts and fruits for alimentary purposes. An expected increase in use of biomass for energy production, as described in Chapter 1, will put further pressure on the forest. Since there is no indication of reduction in the demand of wood for non-energy purposes[96], and since genuine yield increase is not sufficient to make up the new demand, it is reasonable to assume that the overall outtake of wood from forests will have to increase, in order to provide biomass for energy. This will probably stem from either increasing harvest from existing managed forests or by including unmanaged (natural) forests in production, leading to lowering of carbon levels and possible deforestation.

An increased pressure on the world's forests from the production of woody biomass can have several negative environmental impacts, some of which will be explored in this section.

Impact on biodiversity

The rising pressure on the forests means that more and more wood and carbon organic matter is removed. This can cause depletion of the organic matter, that is home to many insects and animals and provide a source of nutrients and organic material necessary for the health of the trees and forest ecosystem. Dead tree trunks slowly release nutrients that the remaining biomass lives of[97]. At the same time, the dead tree is the perfect home for different organisms, insects and animals. Both dead trees and old living trees are crucial for biodiversity in the forest[98]. Extraction of biomass, even from dead materials or forests residues, can therefore potentially be compromising the forest health[99]. Furthermore, a highly managed forest tends to have a monoculture characteristic[100] with short rotations periods. This again leaves less room for other species, both plants, insects, large herbivores and predators.

Depletion of biodiversity will weaken the forest ecosystem and make it more vulnerable to natural stresses, like forest fires, storms or draughts, which are aggravated by climate change. Compromising the biodiversity of the, forest will compromise the whole forest.

Degradation of the forest Carbon Stock

The increasing pressure on the world's forests has contributed to a significant reduction in the global forest carbon level[101]. The world's forests have generally been considered a net sink of atmospheric carbon, contributing to the global mitigation. But the increased pressure on the forests can compromise this sink effect, and forests might already have become a net source of carbon emissions[102]. The degradation of the forest carbon stock is not only adding to the climate crisis, but it is also compromising the potential sink of forests and the possibility of using forest land as a cheap and good natural climate solution[103].

[96] Faostat. 2018: Forestry Production and Trade. Available online: http://www.fao.org/faostat/en/#data/FO
[97] Framstad, E., Wit, H., Mäkipää, R., Larjavaara, M., Vesterdal, L. & Karltun, E. 2013: *Biodiversity, carbon storage and dynamics of old northern forests,* Norden, Nordic Council of Ministers, p. 31. Available online: http://www.diva-portal.org/smash/get/diva2:702580/FULLTEXT01.pdf
[98] Ibid.
[99] European Commission. 2016: *Impact Assessment Sustainability of Bioenergy*, Commission Staff Working Document, SWD(2016) 418 final. Available online: https://ec.europa.eu/energy/sites/ener/files/documents/1_en_impact_assessment_part4_v4_418.pdf
[100] Framstad, E., Wit, H., Mäkipää, R., Larjavaara, M., Vesterdal, L. & Karltun, E. 2013: *Biodiversity, carbon storage and dynamics of old northern forests,* Norden, Nordic Council of Ministers. Available online: http://www.diva-portal.org/smash/get/diva2:702580/FULLTEXT01.pdf
[101] European Commission. 2016: *EU Reference Scenario 2016 - Energy, transport and GHG emissions trends to 2050*. Luxembourg. Available online: https://ec.europa.eu/energy/sites/ener/files/documents/ref2016_report_final-web.pdf
[102] Baccini, A. et al. 2017: *Tropical forests are a net carbon source based on aboveground measurements of gain and loss*, Science, 10.1126/science.aam5962 (2017). Available online: https://carbon.nasa.gov/pdfs/featured_pub_20171005.pdf.
[103] Griscom, B. W. et al. 2017: *Natural Climate Solutions*, Proceedings of the National Academy of Sciences Oct 2017, 114 (44). Available online: http://www.pnas.org/content/114/44/11645.

Need of land areas for biomass production

Compared both to other renewable energy sources (e.g. solar and wind) and to fossil fuels, production of biomass for energy uses very large amounts of land. Energy from biomass use 10-100 time the area of other renewable energy solutions, and up to 10.000 time the area used for fossil fuel productions[104]. With already increasing competition for global land resources[105], increased demand from production of biomass can put further pressure on other land uses, including for food production and water supply. This risk exacerbating existing problems, e.g. conflicts relating to land rights/ownership and food security of vulnerable groups.

Biomass is not a carbon neutral source of energy as it emits CO2 when burned. In the energy sector, biomass is considered carbon neutral because of the political decision to account the emissions from biomass in the land sector. But the assumption of carbon-neutrality does not take into account the heating caused by temporary elevated levels of CO2 in the atmosphere, before some of the carbon is re-sequestered in new tree. Thus, burning biomass for energy has negative effect on the global climate. Furthermore, the increased use of biomass in the energy sector puts pressure on the world's forests, affecting the carbon stock in the forests and the potential of using the world's forests as climate solution.

4. Why discussing biomass is relevant right now

With increasing use of biomass for energy production in both Denmark and around the world, and the resulting stress on forests, debate on the role of woody biomass is highly relevant to current climate and energy policy. Furthermore, several ongoing international negotiations on renewable energy and international accounting rules, can have a significant impact on the future development of the use of woody biomass at an international level. In this chapter, we highlight why a debate on the current and future use of biomass for energy is highly relevant right now.

Large expected increase in the global use of wood for energy

The use of biomass in energy production is seen as an integrated part of a transformation away from reliance on fossil fuels, both in a number of western countries' energy plans and in the world as a whole[106]. The global production of wood pellets continues to rise considerably each year (increased with on average 2.8 million tonnes annually between 2012 and 2016), and countries are increasingly exporting production[107].

The rapid expansion of pellet production in Vietnam could indicate a significant development, especially in the context of the bioenergy pledges provided by large Asian countries like China and India (as part of the BioFuture Platform, described in Chapter 1). If these two major energy consumers are going to transform their energy systems to include more biomass, it can impact the market for woody biomass significantly. To cover 10% of the current energy supplied by coal in China, the global production of wood pellets would have

[104] UNCCD. 2017: *Global Land Outlook*, United Nations Convention to Combat Desertification, p. 216. Available online: www.unccd.int/glo.
[105] Ibid.
[106] IEA. 2017: *Technology Roadmap - Delivering Sustainable Bioenergy*. Available online: https://www.iea.org/publications/freepublications/publication/technology-roadmap-delivering-sustainable-bioenergy.html
[107] Faostat. 2018: *Forestry Production and Trade*. Available online: http://www.fao.org/faostat/en/#data/FO

to increase with 1500%[108]. Such a development could especially put pressure on the forest in countries in Southeast Asia and Africa, with increased demand for outtake of biomass for export[109].

With the planned increases in use of bioenergy from a number of large importing countries and energy consumers, addressing the use of woody biomass in large scale energy production is increasingly relevant.

New decisions on LULUCF Accounting Rules in EU

According to the IPCC LULUCF accounting rules, CO2 emissions from burning of biomass should be accounted for in the land sector, when the biomass is taken out of the forest. The rules on how to register carbon emissions from the land sector, can have significant influence on how much biomass is taken out of the forest for burning in the energy sector. The European Parliament has recently finished negotiations on the future LULUCF accounting rules within the EU[110]. The final vote on the LULUCF rules in the European Council is expected to take place in March 2018. It is possible that the EU LULUCF rules will create precedent for the rest of the worlds LULUCF rules, including the ones used under UNFCCC.

The new European LULUCF rules are set to use 2000-2009 as a reference period for the forest management level[111]. This means that the future forest management between 2021-2030 shall be measured according to the forest management (management practices and intensity plus forest characteristics) in the 2000-2009 reference period[112]. The reference levels are set to account for changes in the intensity by which the European forests are being managed and thus the impact on the sink. As long as a country continue to manage their forests to the same extend (with the same or similar practices and outtake of wood), they can continue to take out a certain amount of biomass, without it being counted in the carbon-emissions accounting.

Furthermore, the EU rules include a flexibility mechanism, which allows Member States to lower their forest sink capacity by a certain percentage, which differs between countries. This will allow for increased outtake of biomass without accounting for the CO2 emissions. However, a country can only reduce its forest management sink if another country is set to overachieve in some of the different land use categories. This is to make sure the overall EU targets are not breached.

It is positive that the EU LULUCF rules will make it compulsory to measure and protect the carbon sink capacity of European forests. But it is negative that the EU rules fails to establish incentives to increase sinks as is required to reach the Paris Agreement targets. The new rules do not contain sufficiently strong measures to make sure these targets are actually achieved and forested countries still have too much room to reduce their forest carbon sink and increase harvest. On top of this, the EU rules are expected to set precedent for the approach used by other countries and possibly for the future accounting guidelines under the UNFCCC.

[108] Using the Total Primary Energy Supply from coal reported by IEA (https://www.iea.org/statistics/statisticssearch/) and the energy efficient for wood pellets used by the Danish Energy Agency (17.5 GJ/t) (Danish Energy Agency. 2011: *Biomass Statistics: Wood pellets* https://ens.dk/service/statistik-data-noegletal-og-kort/energistatistik-metoder-mm).

[109] It is noted, that the latest figures do not show evidence of significant increase in the production of wood pellets for export from Africa or Southeast Asia (except for Vietnam). Thrän et al. 2017. *Global Wood Pellet Industry and Trade Study 2017*. IEA Bioenergy Task 40. June 2017. Available online: http://www.ieabioenergy.com/publications/global-wood-pellet-industry-and-trade-study-2017/

[110] European Commission 2017. *Commission welcomes agreement on key legislation to tackle climate change.* European Commission webpage: https://ec.europa.eu/clima/news/commission-welcomes-agreement-key-legislation-tackle-climate-change_en

[111] Corrected text that the parliament agreed on, is not yet available online. Commissions proposal is available online: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52016PC0479&qid=1518966253646&from=EN

[112] The end of the reference period is defined by when the Renewable Energy Directive entered into force, which has incentivises the use of forest biomass for energy. This makes sure any increase in emissions of biomass energy use after that will be accounted for.

If other coalitions adopted the flexibility mechanism, it could give room for a huge decrease in the global sink capacity.

Ongoing negotiations on emission accounting in the UNFCCC

One of the main issues currently being negotiated by the UNFCCC are the rules and guidelines for the implementation of the Paris Agreement. The "Paris Agreement Rulebook", which should be finalized at COP24 in December 2018, will include guidelines for countries reporting of climate targets under their Nationally Determined Contributions (NDCs)[113]. The rules for NDCs will direct how countries report on their climate actions, including on the emissions of greenhouse gases from the energy and land sectors. NDC reporting will therefore determine future emission accounting in the land sector. If the accounting rules allows an outtake of carbon from the forest without accounting for it, this can incentivize further use of biomass in the energy sector[114].

Complete and accurate accounting rules for both the energy and land sectors are essential to avoid exploitation of the world's forests for bioenergy use. The implementation of the Paris Agreement offers the possibility for addressing loopholes created for bioenergy in the current greenhouse gas accounting under the Kyoto Protocol[115]. If land accounting is too weak, it can end up hiding actual net-emissions if biomass burned for energy production continues to be counted as non-CO2 emitting in the energy sector[116].

The existing guidance for accounting of greenhouse gas inventories (from 2006) is currently being updated by the IPCC[117], planned to be finished in 2019. This update could offer the possibility for improvements on the current rules for accounting of biomass, ensuring that biomass for energy production is comprehensively accounted for. When that is said, the IPCC are limited by the existing decisions governing accounting of land use rules from the UNFCCC, that records emissions from woody biomass in the national account of the country where the tree was cut down, rather than in the country that is burning the biomass[118].

Since a number of countries base their existing NDCs on the guidelines for LULUCF created by the IPCC, it should be a major priority for the UNFCCC to decide on improved accounting principles for the land sector, in particular in relation to bioenergy.

Short timeframe for reaching targets set by the Paris Agreement

According to the IPCC, greenhouse gas emissions should be cut dramatically by 2050[119], and shortly thereafter the development should change to the world being carbon negative, with a larger uptake than emissions. Some organisations have estimated that, since we are now emitting more CO2 than we should according to the IPCC carbon budget, the world should become carbon neutral already in 2040, and carbon negative after that[120].

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[113] Negotiated under the Ad Hoc Working Group on the Paris Agreement http://unfccc.int/bodies/apa/body/9399.php.

[114] Haberl, H. et al. 2012: *Correcting a fundamental error in greenhouse gas accounting related to bioenergy*, Energy Policy 45(2012)18–23. Available online: https://www.sciencedirect.com/science/article/pii/S0301421512001681

[115] Krug, J.H.A. 2018: *Accounting of GHG emissions and removals from forest management: A long road from Kyoto to Paris*. Carbon Balance Manage (2018) 13:1. Available online: https://cbmjournal.springeropen.com/articles/10.1186/s13021-017-0089-6

[116] FERN et al. 2016. *Why LULUCF cannot ensure that bioenergy reduces emissions.* Briefing Note. Online Available: http://www.fern.org/sites/fern.org/files/Fern%20LULUCF%20briefing%20paper.pdf

[117] Updating of the guidelines are done by the IPCC Task Force on National Greenhouse Gas Inventories: https://www.ipcc-nggip.iges.or.jp/

[118] UNFCCC Decision 2/CMP.7 from 2011 on *Definitions, modalities, rules and guidelines relating to land use, land-use change and forestry activities under the Kyoto Protocol*. Available online: http://unfccc.int/resource/docs/2011/cmp7/eng/10a01.pdf

[119] In order for it to be "likely" that global warming is kept below 1.5 degrees. IPCC. 2014: *Climate Change 2014 Synthesis Report*. Contributions of Working Group I, II and III to the Fifth Assessment Report of the IPCC.

[120] Greenpeace Denmark's calculations available online: http://www.greenpeace.org/denmark/da/nyheder/blog/forslag-til-nye-klima-og-energiml-er-de-ambit/blog/60785/

Extraction of woody biomass for energy production most often stems from managed forests. But forest management can be done in a number of different ways. Forest is in some places clear cut and then replanted. In other areas, the majority of biomass stems from thinnings and residues, though thinning can mean cutting down old trees as well. Depending on the forest management system, the re-sequestration of carbon will take from a few decades up to even centuries[121]. This means that the burning of biomass will not be carbon neutral within the timeframe of the Paris Agreement. The installation of more biomass consuming power plants in Denmark and the rest of the world, will create a global biomass consumption, that can compromise the targets set by the Paris Agreement, which is why it is highly relevant to consider the use of biomass right now.

To achieve the goal in the Paris Agreement, we must work towards negative emissions by the middle of the 21st century - which means that global uptake of CO2 should be larger than emissions released into the atmosphere. Forests, that are restored to increase carbon sink, are one of the cheapest and easiest climate solution, with the potential to provide considerable negative emissions, and this has recently received increased attention[122]. Several reports illustrate[123] the potential for extra carbon sequestration in the world's forests, with one estimate suggesting that forest solutions could account for around 13% of the globally needed emission reductions between now and 2050[124]. Forests therefore holds considerable potential for contributing to climate solutions by increasing the already considerable sink effect they provide. Extraction of biomass for energy production contradicts the efforts to improve global sink effects from natural sources. It is estimated by the EU that the current and planned forest management, will lead to a decrease in the carbon sink effect of the European forests, primarily due to increased extraction of biomass for energy use[125]. Such a development is not compatible with the targets and timeframe provided by the Paris Agreement.

[121] Agostini, A., Giuntoli, J. & Boulamanti, A. 2014: *Carbon accounting for forest bioenergy - Conclusions and recommendations from a critical literature review*, European Commission - Joint Research Center, Report EUR 25354 EN. Available online: https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/carbon-accounting-forest-bioenergy-conclusions-and-recommendations-critical-literature
Ter-Mikaelian, M. T., Colombo, S. J., and Chen, J. 2015. *The Burning Question: Does Forest Bioenergy Reduce Carbon Emissions? A Review of Common Misconceptions about Forest Carbon Accounting,* Journal of Forestry, January 2015. Available online: https://www.researchgate.net/publication/271224456_The_Burning_Question_Does_Forest_Bioenergy_Reduce_Carbon_Emissions_A_Review_of_Common_Misconceptions_about_Forest_Carbon_Accounting
Lamers, P. & Jungninger, M., 2013. *The 'debt' is in the detail: A synthesis of recent temporal forest carbon analyses on woody biomass for energy,* Biofuels, Bioprod. Bioref. 7:373–385 (2013). Available online: https://www.researchgate.net/publication/259576449_The_%27debt%27_is_in_the_detail_A_synthesis_of_recent_temporal_forest_carbon_analyses_on_woody_biomass_for_energy
[122] Pearce, F. 2017: *Return of the Trees,* Report by FERN and Rainforest Foundation Norway. Available Online: http://www.fern.org/sites/fern.org/files/Fern%20-%20Return%20of%20the%20Trees%20%28ENG%29.pdf
Climate Action Network, 2018. *Position Paper on Forest and Land Restoration – Natural Ways of Limiting Temperature Rise to Below 1.5°C.* Available Online: http://www.climatenetwork.org/sites/default/files/can_land_and_forest_position_final.pdf
Houghton, R. A., et al. 2015: *Forests and Land Use: Undervalued Assets for Global Climate Stabilization.* Policy Brief for Woods Hole Research Center. Available Online: http://whrc.org/wp-content/uploads/2015/06/PB_Forests_and_Land_Use.pdf
[123] Griscom, B. W. et al. 2017: *Natural Climate Solutions*, Proceedings of the National Academy of Sciences Oct 2017, 114 (44). Available online: http://www.pnas.org/content/114/44/11645;
Kartha, S. & Dooley, K. 2016: *The risks of relying on tomorrow's 'negative emissions' to guide today's mitigation action*. Report for SEI. Available Online: https://www.sei-international.org/mediamanager/documents/Publications/Climate/SEI-WP-2016-08-Negative-emissions.pdf
[124] Griscom, B. W. et al. 2017: *Natural Climate Solutions*, Proceedings of the National Academy of Sciences Oct 2017, 114 (44).
[125] European Commission. 2016: *EU Reference Scenario 2016 - Energy, transport and GHG emissions trends to 2050*. Luxembourg. Available online: https://ec.europa.eu/energy/sites/ener/files/documents/ref2016_report_final-web.pd

Conclusion

Biomass used for energy production has increased considerably over the last 15 years, and several countries expect to further emphasize bioenergy in the future. The use of biomass in energy production is often considered carbon neutral in a climate context. This is based both on the expectation that emissions are accounted for in the land sector, and the assumption that biomass is part of a short carbon cycle, where the CO2 emitted to the atmosphere will be reabsorbed by tree growth. But biomass emits CO2 when it is burned and should not be considered as an inherently carbon neutral fuel source nor a good solution to climate change.

Current and future increases in large scale use of wood in energy production, put serious pressure on the world's forests. This can lead to increases in emissions and to a decrease in the global forest carbon stock, and cause harm to forest wildlife, biodiversity, and local livelihoods. When considering the use of biomass for energy production, all the environmental and social consequences have to be accounted for.

Use of biomass is encouraged by existing international accounting rules for land use and energy, and by national policies and subsidies. New accounting rules and modalities are currently being negotiated in both the EU and the UNFCCC. If these rules do not properly address the use of biomass in energy production and the associated emissions, it risks undermining current climate efforts, which in turn will make the targets defined in the Paris Agreement unattainable. Discussion of the climate aspects of biomass is therefore urgent and highly relevant in the current climate change debate.

As one of the largest importers of woody biomass in the world, Denmark holds a big responsibility. Biomass already constitute a significant part of the Danish energy and climate plans. In addition, the decommissioning of several large coal-based plants, can further increase the Danish consumption of biomass. As a rich country with a significant green profile, Denmark has a responsibility to develop climate solutions and technology that can be adopted around the world. The heavy reliance on imported wood in Danish energy cannot be considered as a sustainable climate solution, that should be used by other countries. Denmark is therefore a good place to start working on a change in the use of biomass.

Glossary

Accounting - Calculation of a country's greenhouse gases against targets for reductions of emissions that is officially reported under the UNFCCC. Note that while a number of countries report their emissions to the UNFCCC, not all of these account the emissions against defined targets. Under the Paris Agreement all parties will account against individual targets set out in the countries' NDCs.

Biofuels - Solid and liquid fuels derived from biological material, including organic waste from industry and agriculture.

Biomass - Solid and liquid matter derived from biological material, including organic waste from industry and agriculture. The most common biomass is either wood or straw. This report primarily refers to woody biomass as biomass.

Forest management - Activities related to growing of trees and harvesting of wood from forests and plantations. In this report, this refers primarily to the extend wood and biomass is extracted from the forests.

Liquid biofuel - Biofuels that are used in liquid and/or gaseous form, including biogas and biodiesel deriving from dead organic material.

Modern energy production - Refers to centralised energy production in large scale plants and to modern decentralised energy production, including the use of biofuels like biodiesel, biogas, wood pellets and wood chips in both individual households and central power and heating systems.

Solid biomass - Biomass that is used in solid forms, including wood, charcoal, straws and biodegradable waste.

Traditional energy production - Refers to decentralised energy use in developing countries, including the use of biomass like fuelwood, charcoal and similar fuels in open fires and simple ovens.

Woody biomass - Solid biomass deriving from trees.

Acronyms

CO_2 - Carbon dioxide

Ej - Exajoule = 10^{18} joule

EU - European Union

IEA - International Energy Agency

IPCC - Intergovernmental Panel on Climate Change

LULUCF - Land Use Change, Land Use Change and Forestry - Sector used in accounting and reporting of greenhouse gases to the UNFCCC.

Mt - Megaton = 1,000,000 tonnes

NDCs - Nationally Determined Contributions - Commitments made by parties to the Paris Agreement regarding their targets for emissions reductions and climate change activities.

OECD - Organisation for Economic Co-operation and Development

Pj - Petajoule = 10^{15} joule

UNFCCC - United Nations Framework Convention on Climate Change - Refers to both the convention signed by states and to the institutional setup surrounding the convention, including the UNFCCC secretariat.

Tj - Terajoule = 10^{12} joule

Forests of the World is an environmental NGO founded in Denmark in 1983 with the objective to conserve and manage the world's forests in a sustainable way. We create opportunities for communities and people, who aspire to save the forests of the world. We also aim to demonstrate and prove the value of the living forest through campaigns, consumer information, training, cooperation, and concrete work in and around the rainforest.

We work with international networks and partners in Latin America and Africa from offices in Aarhus and Copenhagen in Denmark and La Ceiba in Honduras.

The vision of Forests of the World is a world with rich forest nature.

In pursuit of our vision, we will:

- ensure ecologically, socially and economically sustainable use of the world's forests, in order to conserve or (re)generate valuable biologically diverse forest;
- support indigenous peoples and other local forest communities in their struggle for the right to live with dignity, thus empowering them to preserve their forest and way of life;
- engage citizens in the protection of nature, put the forest on the political agenda, and inform about the values lost when forests are destroyed and wild species-rich natural environments disappear;
- put the forest on the global agenda concerning climate, inequality, and development.

The development objective of our international work is:
To use individual and collective human rights and sustainable value chains as the foundation for conservation of the tropical forests benefitting the biological and cultural diversity, the global climate, as well as the living conditions of indigenous peoples and communities who depend on the forests.

We aim to contribute to the Sustainable Development Goals of the United Nations, and our strategic approaches are developed within the following areas:

- Forest, Climate & Biodiversity
- Sustainable Value Chains - Forest Management (FSC), Agroforestry, Tourism (GSTC) and Corporate Social Responsibility (CSR)
- Human Rights Based Approach
- Indigenous Peoples
- Partnership & Organization
- Gender & Equality
- Sustainable Development Goals

You can read more about our work, strategies and contact information on our website www.forestsoftheworld.org