REPORT

Methane Emissions in a Danish Context

Mapping of Denmark's current and projected methane emissions and how we can reduce them

Green Transition Denmark

Green Transition Denmark is an independent environmental organization that works to promote a green and sustainable transformation of society.

The Methane Matters Coalition consists of experienced non-governmental organisations working to significantly reduce methane emissions in the relevant agriculture, waste and energy sectors by 2030. Green Transition Denmark is a partner organisation of the Coalition.

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RECOMMENDATIONS

1. The Danish Government must develop a National Methane Action Plan with a reduction target of 40-45%.

2. The short-term perspective (GWP20) should be incorporated in the decision-making as the deadline of most climate goals are within the next 20-25 years.

3. Danish agriculture should be transformed resulting in less animal production and more plant-based food production

4. The trade-offs in the use of mitigation technologies must be thoroughly explored and taken into consideration before they are implemented.

5. Oil and fossil natural gas extraction must be phased out before 2040. This is possible, according to our recent energy transition scenario.

6. The target of phasing-out the use of oil and gas boilers must be advanced to 2030.

7. Methane leakage from biogas plants must be closely monitored and addressed, including the real impact of the new regulation on methane leakage.

8. The production and use of biogas must be in accordance with a significant reduction in livestock numbers and feedstock for plants should primarily be based on residues.

9. Biogas should only be used where there are no better alternatives – e.g. in peak load production (supplementary to wind and solar power) and in industries requiring high temperatures.

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Danish Summary

Metan er en kortlivet, men kraftig drivhusgas, der er årsag til cirka en tredjedel af den totale globale opvarmning, vi oplever i dag. Metan opvarmer planeten omkring 30 gange mere end CO2 beregnet over en 100-årig periode, men over 80 gange mere over en 20-årig periode. Jo mere bekymrede vi er for global opvarmning på den korte bane, jo mere bør vi derfor fokusere på at reducere metan-udledninger. Med de fleste klimamål inden for de næste 20-25 år, og en snarlig overskridelse af 1.5°C-målet og flere 'tipping points', kan reduktioner af metan-udledning til atmosfæren skabe hurtige og markante effekter på opvarmningen og købe tid til mere langsigtede CO2-reduktionsstrategier.

I 2021 lancerede EU sammen med USA the Global Methane Pledge (GMP) på COP26, hvis primære mål er at reducere de globale metan-udledninger med 30% i 2030 i forhold til 2020. I marts 2024 havde 158 lande skrevet under på GMP, deriblandt Danmark. Fremskrivninger fra Klima, Energi og Forsyningsministeriet viser dog, at Danmark kun ser ud til at reducere deres metan-udledninger med 10-15%. De danske metan-udledninger kommer fra henholdsvis landbrugs-, affalds-, energi- og LULUCF-sektoren, hvor landbruget står for klart den største andel af udledningerne.

Effekterne af den grønne trepart er ikke medtaget, da effekterne heraf endnu er usikre. Tilskuddet til fodertilsætningsstoffet Bovaer vurderes at bidrage til en metanreduktion på op til fem procentpoint i 2030 i forhold til 2020, mens det er usikkert, hvor meget antallet af husdyr vil blive reduceret som følge af aftalen og dermed, hvad den tilhørende metanreduktion vil være. Derudover vil aftalen øge metanudledningen fra lavbundsjorder, men den samlede klimaeffekt af vådlægningen vil dog være positiv. Rådet for Grøn Omstilling forventer ikke, at effekterne af trepartsaftalen vil reducere metanudledningen tilstrækkeligt og er fortsat skeptiske over for potentielle negative sideeffekter af Bovaer.

De største kilder til metan-udledninger i Danmark er husdyrenes fordøjelsesprocesser og husdyrgødning i landbrugssektoren, vådområder i LULUCF-sektoren, deponering af fast affald og metan-lækage fra biogasanlæg i affaldssektoren, samt flygtige emissioner fra gas i energisektoren. For at leve op til hvad Danmark skrev under på i the Global Methane Pledge, skal Danmark udforme en national metan-handlingsplan, der viser hvordan Danmark vil reducere sine metan-udledninger med mindst 30% i 2030 i forhold til 2020.

Rådet for Grøn Omstilling anbefaler, at den danske regering udvikler en national metan-handlingsplan med et reduktionsmål på 40-45 %. Dette reduktionsmål er nødvendigt for at sikre overensstemmelse med Paris-aftalen og the Global Methane Pledge, og er vurderet omkostningseffektivt og gennemførligt af FN's miljøprogram. Fokus skal være på at transformere landbruget mod mere plantebaseret produktion for at reducere metan-udledningerne fra sektoren, der i dag står for 80% af udledningerne. Dette kan kun lade sig gøre ved en kombination af strukturel og teknologisk omstilling. Det skal samtidig sikres, at teknologiske virkemidler ikke har negative sideeffekter, f.eks. på dyrevelfærd og biodiversitet.

Metan-udledninger fra energisektoren bør reduceres ved at udfase olie- og naturgasudvinding inden 2040. Installation af nye olie- og gasfyr bør straks forbydes, og de eksisterende bør udfases senest i 2030.

Desuden skal metan-lækage fra biogasanlæg overvåges, grænseværdierne skal gradvist skærpes, og de skal håndhæves. Biogasproduktionens størrelse skal kunne kombineres med en betydelig reduktion i antallet af husdyr. Biogas skal kun bruges, hvor der ikke er bedre alternativer, f.eks. som supplement til vind og sol, samt til forsyning af industrier med særlige behov.

Executive Summary

Methane is a short-lived but powerful greenhouse gas that is responsible for about a third of the total net global warming we are experiencing today. Methane warms the planet about 30 times more than CO_2 calculated over a 100-year period, but over 80 times more over a 20-year period. Therefore, the more concerned we are about global warming in the short term, the more emphasis we must put on cutting methane emissions. With most climate targets due to be met within the next 20-25 years, and the threat of soon exceeding the 1.5°C target and multiple 'tipping points', reducing methane emissions can have a rapid and significant impact on global warming and buy time for longer-term CO_2 mitigation strategies.

In 2021, the EU and the US launched the Global Methane Pledge (GMP) at COP26. The main goal of the GMP is to reduce global methane emissions by 30% in 2030 compared to 2020. By March 2024, 158 countries had signed the GMP, including Denmark. However, projections from the Danish Ministry of Climate, Energy and Utilities show that Denmark will only be reducing its methane emissions by 10-15%. Danish methane emissions come from the agriculture, waste, energy and LULUCF sectors, with agriculture accounting for by far the largest share of emissions.

The effects of the Danish political agreement - the Green Tripartite Agreement - are not included as the effects are still uncertain. The subsidy for the feed additive Bovaer is estimated to contribute to a methane reduction of up to five percentage points in 2030 compared to 2020, while it is uncertain how much livestock numbers will be reduced as a result of the agreement, and thus what the associated methane reductions will be. In addition, the agreement will increase methane emissions from peatlands, but the overall climate effect of rewetting will be positive. Green Transition Denmark does not expect the effects of the tripartite agreement to sufficiently reduce methane emissions and remains skeptical about possible negative side effects of Bovaer.

The largest sources of methane emissions in Denmark are enteric fermentation and manure management in the agriculture sector, wetlands in the LULUCF sector, solid waste disposal and methane leakage from biogas plants in the waste sector, and fugitive emissions from gas in the energy sector. In order to fulfil Denmark's commitment to the Global Methane Pledge, Denmark must develop a National Methane Action Plan showing how Denmark will reduce its methane emissions by at least 30% in 2030 compared to 2020.

Green Transition Denmark recommends that the Danish government develops a National Methane Action Plan with a reduction target of 40-45%. This reduction target is necessary to ensure compliance with the Paris Agreement and the Global Methane Pledge and has been deemed cost-effective and feasible by the UN Environment Programme (UNEP). The focus should be on transforming agriculture towards more plant-based production to reduce methane emissions from the sector, which currently accounts for 80% of Danish methane emissions. This can only be achieved through a combination of structural and technological transformation. At the same time, it must be ensured that technological measures do not have negative side effects, for example on animal welfare and biodiversity.

Methane emissions from the energy sector should be reduced by phasing out oil and natural gas extraction by 2040. The installation of new oil and gas boilers should be banned immediately, and existing boilers should be phased out by 2030 at the latest. In addition, methane leakage from biogas plants must be monitored and limits gradually tightened and enforced. The scale of biogas production must be compatible with a significant reduction in livestock numbers. Biogas should only be used where there are no better alternatives, e.g. to supplement wind and solar power, and to supply industries with special needs.

The Global Methane Pledge (GMP)

In 2021 the EU and the United States together launched the Global Methane Pledge (GMP) at COP26 in Glasgow to accelerate action to reduce methane emissions. The main goal of the Pledge is to reduce global methane emissions by 30% in 2030 compared to 2020 levels. The reduction target is global rather than national, meaning that each participant of the GMP has agreed to *take voluntary actions to contribute to a collective effort to reduce global methane emissions by at least* 30%[2]. The pledge emphasises the importance of rapidly reducing methane emissions to limit global warming to 1.5 °C, in line with the Paris Agreement.

In March 2024 the GMP counted 158 participants, who together account for just over 50% of global anthropogenic methane emissions.

The participants have committed to taking comprehensive national actions to achieve the reduction target by *focusing on standards to achieve all feasible reductions in the energy and waste sectors and seeking abatement of agricultural emissions through technology innovation as well as incentives and partnerships with farmers*[3]. Denmark, led by the former climate and energy minister Dan Jørgensen, signed the GMP at its launch in 2021, and is thereby one of the 158 countries that has committed to collectively reduce the global methane emissions with 30 % and to take comprehensive domestic actions to achieve that target. As not all countries in the world have signed the GMP, calculations by the UK think tank Green Alliance show that all GMP participants must reduce their methane emissions by more than 40% to ensure that the GMP's 30% reduction target is met[4].

Figure 1: Participants of the GMP (in blue)[5]

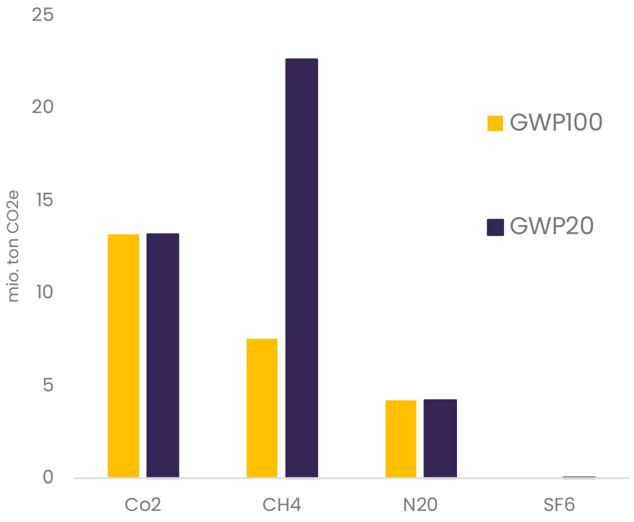
Why is Methane Important?

Methane (CH4) is the second most important anthropogenic greenhouse gas (GHG) in terms of its warming effect[6]. According to the sixth assessment report from the Intergovernmental Panel on Climate Change (IPCC), about a third of the total net global warming since pre-industrial levels is due to higher methane concentrations[7]. Methane warms the planet about 30 times more than CO2 calculated over a 100-year period, but over 80 times more over a 20-year period[8]. This means that the global warming potential (GWP) of methane is about three times higher in the short term (20 years) than in the long term (100 years).

The GWP describes the total warming effect caused by the instantaneous emission over the entire period (in this case over 20 or 100 years), i.e. 1 tonne of methane over 100 years has a warming effect equivalent to 28 tonnes of CO2, while 1 tonne of methane over 20 years has a warming effect equivalent to 84 tonnes of CO2[9]. The difference in the GWP of methane is due to the short lifetime of methane in the atmosphere of 12-15 years. The high GWP of methane compared to carbon dioxide in the short term makes methane reductions an attractive target for rapidly mitigating global warming in the near term.

This is reflected in Figure 2, which shows the projections of Danish greenhouse gases in 2030, calculated in CO2 equivalents based on the GWP of the gases over 20 and 100 years. In the short term, methane emissions account for a much higher proportion of the global warming effect of greenhouse gas emissions, which is why methane reductions are much more important in this perspective than reductions in carbon dioxide or nitrous oxide. In other words, the more concerned we are about short-term global warming, the more emphasis we must put on cutting methane emissions.

Figure 2: The Danish projected greenhouse gas emissions in 2030 based on GWP100 and GWP20[10]



Global Warming Potential

Currently, most climate-models use a 100-year perspective in their judgements of the temperature effects of greenhouse gases, this includes the Intergovernmental Panel on Climate Change (IPCC)[11]. The climate projections that compare the warming effect of different greenhouse gases look 100 years ahead to 2100. But the situation has changed since the decision was taken to focus on the 100-year perspective. With greenhouse gas emissions remaining high, climate change accelerating globally, and climate targets for 2030 and 2050 approaching, a 10–25-year time horizon is much more relevant for assessing how to best mitigate climate change. In this perspective, methane emissions have a much larger impact on the overall temperature rise in the near future.

The 100-year perspective also misses the threat of 'tipping points' that will result in irreversible changes and damage the planet's life-support systems when crossed[12]. With the current warming level five major tipping points are at risk of being crossed, and if the 1.5°C global warming is exceeded three more tipping points are at risk of being crossed (see the box below). The short lifetime of methane could be the key to avoiding the harmful tipping points of climate change and buying time for longer-term CO2 mitigation strategies. Therefore, the rapid effect, and thus importance, of methane reductions must be considered in policy decisions and actions.

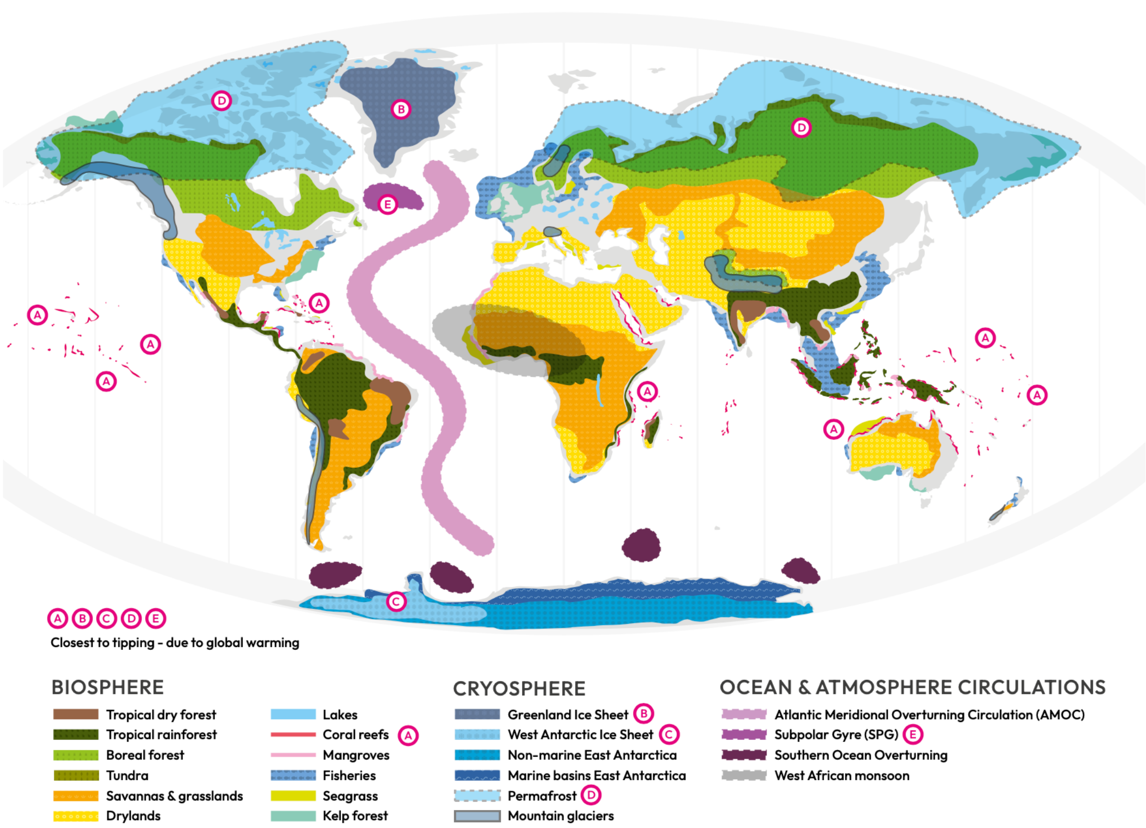
Reducing methane emissions is not only an effective way to rapidly reduce global warming, but also to improve human and ecosystem health. Methane contributes to the formation of ground-level ozone, and thus to air pollution, which causes *significant impacts on human health and vegetation, including agricultural crops, forests and other plants, as it reduces their growth rates and yields and has negative impacts on biodiversity and ecosystem services*[13].

In addition, ozone air pollution causes about one million premature deaths a year worldwide (about 24.000 in the EU[14]), and economic losses due to reduced crop productivity[15]. Reducing methane emissions therefore contributes both to mitigating climate change and to improving human and ecosystem health through better air quality.

Tipping Points

At today's 1.2 °C global warming five major tipping points are at risk of being crossed. If they are crossed, it will result in irreversible changes and damage the planet's life-support systems. These are warm-water coral reefs, the ice sheets of Greenland and West Antarctica, the North Atlantic's Subpolar Gyre circulation, and parts of the permafrost (see Figure 3). If the 1.5 °C global warming is exceeded three more potential tipping points become vulnerable: boreal forest, mangroves and seagrass meadows.

Figure 3: Parts of the Earth system identified as tipping points by Global Tipping Points Report[16]

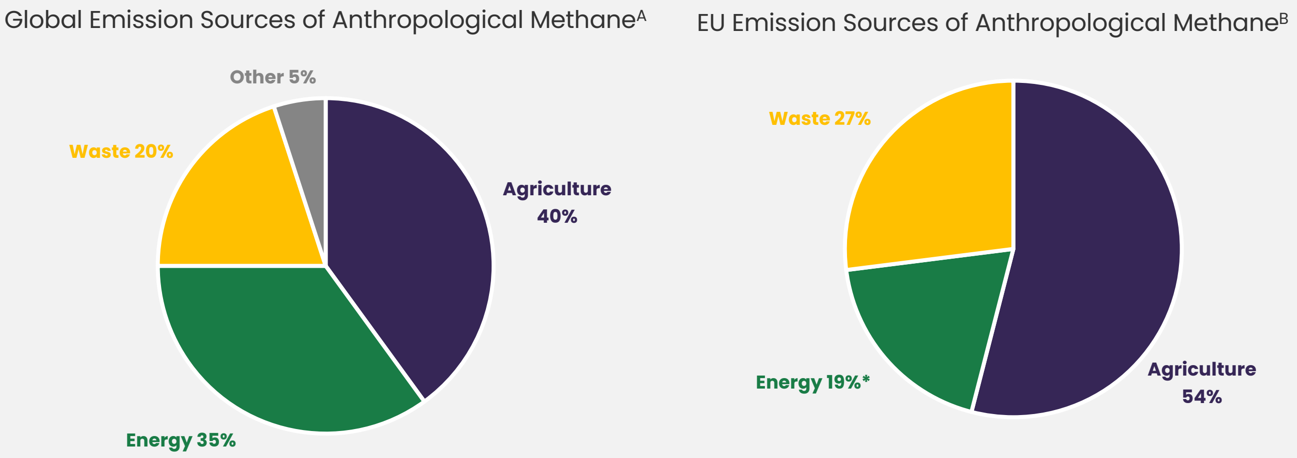


Sources of Methane Emissions

Global methane emissions come from both natural and anthropogenic sources, i.e. emissions resulting from human activities. Natural emissions account for around 40% of global methane emissions and come mainly from wetlands[17]. The anaerobic soil conditions that are a natural function of wetlands lead to the release of methane, but at the same time wetlands also serve as carbon sinks, regulate the water cycle and support 40% of the world's biodiversity[18]. Anthropogenic emissions account for 60% of the emissions and the main sources of these emissions are agriculture (animal husbandry and land use), energy (extraction and transport of fossil fuels) and waste (landfills and wastewater)[19].

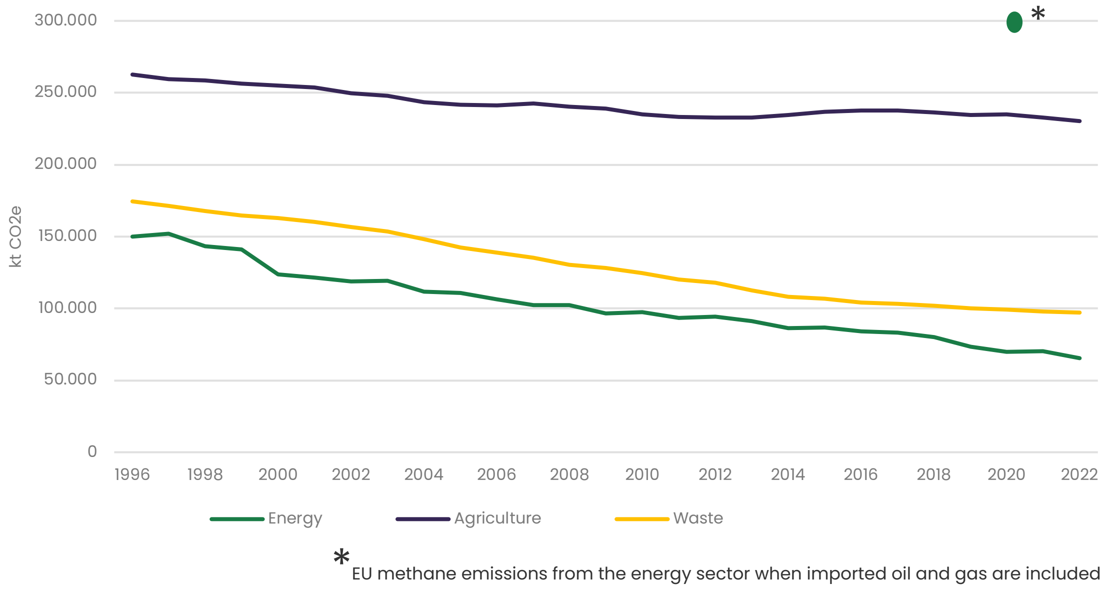
As shown in Figure 4, agriculture is the largest contributor to methane emissions both globally and in the EU, accounting for 40% and 54% of methane emissions respectively. The energy sector is the second largest emitter of methane globally, but the third largest in the EU. One reason for this difference is that methane emissions linked to fossil fuel imports are not included in the inventory for EU presented in Figure 4. As shown in Figure 5, EU's methane emissions from the energy sector would be much higher if imported oil and gas were included. Within the EU, methane emissions from the waste and energy sectors have decreased since the 1990's, while the emissions from agriculture have remained more stable.

Figure 4: Global and EU Emission Sources of Anthropogenic Methane[20]



*This does not include methane emissions linked to fossil fuel imports.
(The EU relies on imports for 70% of its coal consumption, 97% of its consumption and 90% of its fossil gas consumptions.)

Figure 5: Development of EU's methane emissions[21]



National Methane Action Plans

As part of the commitment to the Global Methane Pledge (GMP), countries are expected to submit a Methane Action Plan outlining existing policies and future activities to reduce methane by 2030 and beyond. As of October 2023, nearly 60 governments and the European Union have completed or are in the process of completing their National Methane Action Plans[22]. Among the Nordic countries, Denmark is the only country that has not submitted a Methane Action Plan[23]. Among the countries that have submitted their Methane Action Plan, the expected methane reductions between 2020 and 2030 vary widely. For example, Iceland expects its methane emissions to decrease by 1%, Sweden by 17%, the EU by 23%, and Canada by 35%, while projections show that Denmark's methane emissions will decrease between 10-15% in 2030 compared to 2020[24].

One reason for the large variation in the expected methane reductions across countries is the difference in the size of the different sectors. The GMP states that the energy sector has the greatest potential for targeted reductions by 2030[25]. Methane emissions from agriculture are, according to the GMP and its initiators, USA and the EU, more challenging to reduce due to high costs and the nature of the biological processes involved. Therefore, reductions will require technological innovation as well as incentives and partnerships with farmers, according to the EU[26]. Most proven technologies and practices, particularly in the fossil fuel and waste sectors, can be implemented at negative or low cost, making methane reductions in these sectors more accessible[27]. But abating methane emissions from agriculture can also be addressed in a more systemic way by changing what we produce. Since the vast majority of methane emissions stem from animal husbandry, it would lead to substantial reductions if we transformed our production systems towards producing less animal products and more plant-based food for human consumption.

In its Methane Action Plan, the EU specifically mentions the challenges of high costs and biological processes associated with methane reductions in the agriculture sector as a reason why the EU will not reduce its methane emissions by 30% in 2030 compared to 2020. Methane emissions in the energy and waste sectors will be reduced by more than 30% over this period, but as most of the EU's methane emissions come from the agriculture sector, where emissions by the sector and the authorities are regarded as harder to reduce, the EU will not meet the 30% reduction target[28]. If the EU makes systemic changes to the agricultural production, greater reductions could be achieved. The 30% reduction target could arguably be set higher considering the effects of an agricultural production system change.

How to develop a Danish Methane Action Plan?

EU's Methane Action Plan, as well as those of the other Nordic countries, is more or less structured around five building blocks developed by the Climate and Clean Air Coalition (CCAC). The five building blocks are listed in the box below. Denmark can therefore easily use these building blocks to develop a Danish Methane Action Plan.

The reduction target in the Danish Methane Action Plan should be at least a 30% reduction (in line with the GMP) by 2030, but preferably of a 40-45% reduction by 2030, which is considered both cost-effective and feasible in the Global Methane Assessment[29]. This target must be the focal point of a Danish Methane Action Plan that sets out the path with concrete and new policies that makes it possible to achieve the reduction target.

In the Danish context, it is specifically urgent to address methane from the agriculture sector and seek pathways to reduce the sector's emissions, e.g. by addressing the size of livestock production, as the current level is far from sustainable (this will be elaborated below). In order to lead to real reductions in methane emissions, the plan must both set specific sub-targets and outline concrete measures.

The Five Building Blocks of a National Methane Action Plan Developed by CCAC[30]

Building Block #1 - Emissions: Quantification of national total methane emissions disaggregated by major source sectors for recent historic years

Building Block #2 - Analytics: Data, tools and methods to identify, evaluate and prioritise methane mitigation *measures* through quantitative assessment of the emission reduction and additional benefits achievable from their implementation

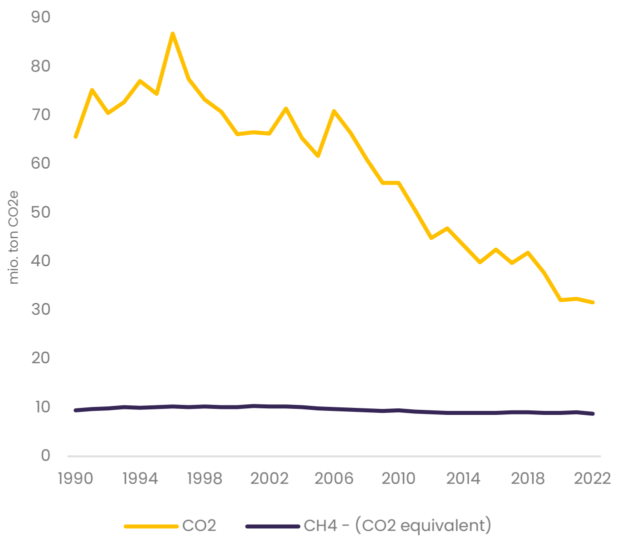
Building Block #3 - Targets: Communicated target that outlines a commitment that will achieve a reduction in methane emissions

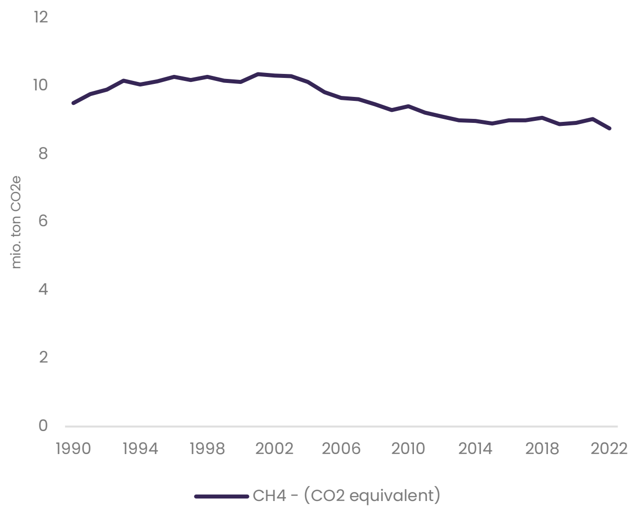
Building Block #4 - Implementation Pathways: A concrete set of actions that provide a clear pathway to the implementation of priority methane mitigation measures, accounting for different types of regulatory, legislative, infrastructure, financing, incentive, monitoring and enforcement, communication and other actions necessary for implementation. Also accounting for barriers to implementation and how these can be overcome, as well as how these actions can be turned into fundable projects.

Building Block #5 - Monitoring, Reporting and Verification: Systems in place to sustainably track progress on i) implementation of priority measures, ii) actions needed for their implementation and iii) impacts from their implementation.

Sources of Methane Emissions in Denmark

Figure 6: Development in Danish methane emissions compared to Danish CO2 emissions[31]





While total Danish CO2 emissions have decreased since 1990, Danish methane emissions have been much more stable, with a small decrease since 1990 (see Figure 6). The current Danish methane emissions come mainly from agriculture, the waste sector, and the energy sector. Denmark differs from both global and EU distribution of emissions in how much agriculture contributes to the national methane emissions. Agriculture accounts for 80% of methane emissions in Denmark (see Figure 7), while it "only" accounts for 54% of methane emissions in the EU[32]. Agriculture is therefore the main source of methane emissions. Where the Danish methane emissions from the energy sector and partly the waste sector have decreased since 1990, methane emissions from the agriculture sector have remained stable and high (see Figure 8).

Figure 7: Danish Methane Emissions in 2023[33]
(IPCC Sectors)

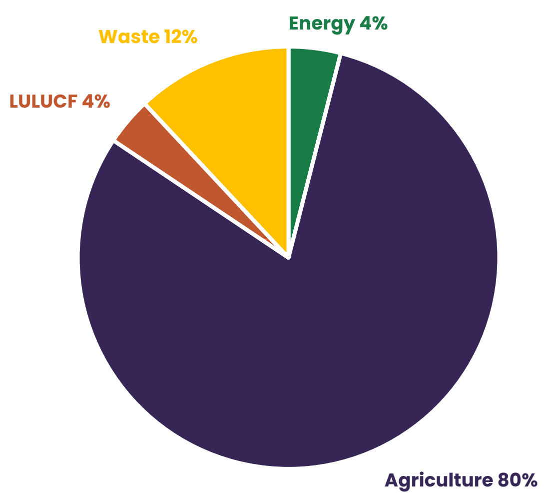
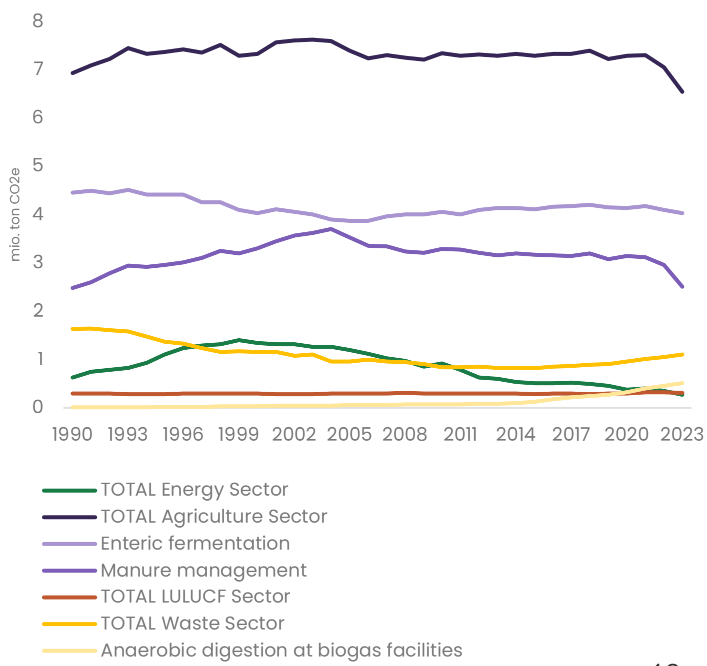
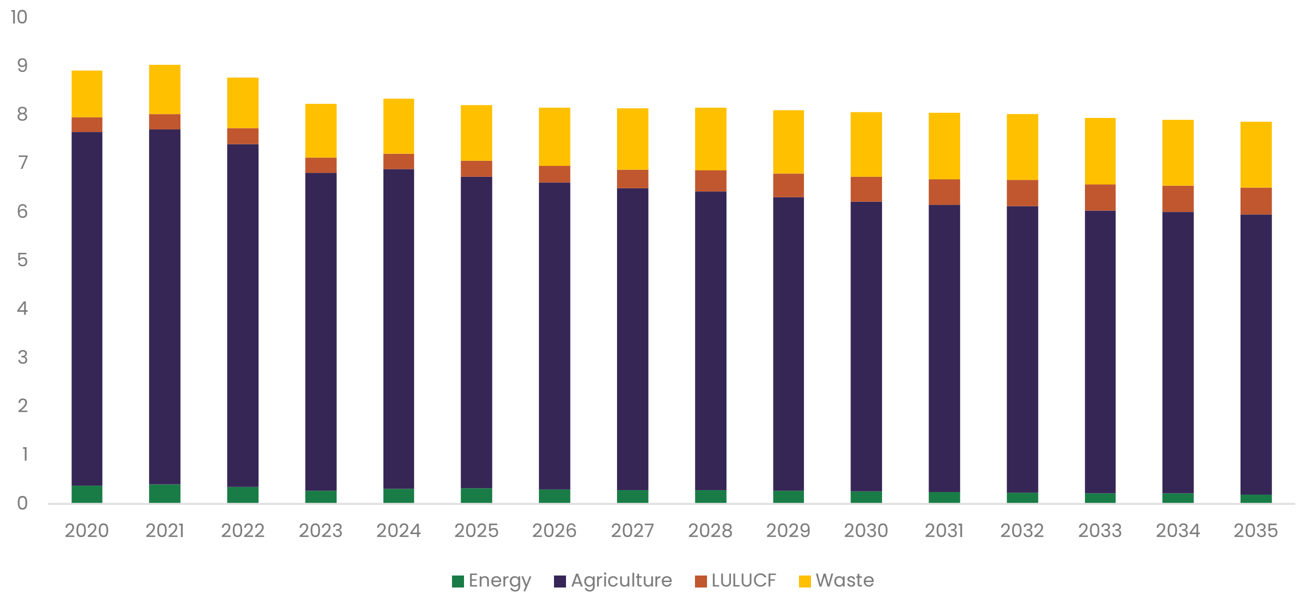


Figure 8: Development of Danish Methane Emissions[34]
(Sector Level)



Projection of Danish Methane Emissions

Figure 9: Projection of Danish Methane Emissions from 2020-2035[35]
(Mio. Ton Co2e based on GWP100)



The 2024 projections on the development of greenhouse gas emissions, published annually by the Danish Ministry of Climate, Energy and Utilities, show that Danish methane emissions are expected to decrease in the future[36]. The decrease in methane emissions is expected to occur in the energy and agriculture sectors, while methane emissions are expected to increase in the waste and in the Land Use, Land Use Change and Forestry (LULUCF) sectors. However, the increase in methane emissions from the LULUCF-sector is due to an increase in wetlands, as carbon-rich agricultural land is set-aside and rewetted[37]. Despite the resulting increase in methane emissions, rewetting of carbon-rich agricultural land has a significant net positive effect on the climate of 10-40 tonnes of CO2 per hectare, as wetlands also serve as carbon sinks[38]. Rewetting also entails positive effect on the aquatic environment, as rewetting reduces nitrogen leaching[39].

Overall, Danish methane emissions are projected to decrease by 10-15% in 2030 compared to 2020. Whether the reduction will be 15% or 10% depends on whether a regulation on methane leakage from biogas production is included, as it is expected to decrease methane emissions from biogas production. There is currently no ex-post analysis of the effect of the regulation, which is why it is not directly included in the projections of total methane emissions. If the regulatory potential regarding methane leakage is fully realized, the waste sector will decrease its methane emissions by 16% in 2030 compared to 2020. Including this potential in the projection thus changes the outcome significantly.

The effects of the new Danish political agreement - the Green Tripartite Agreement - are not included in the projections of methane emissions. Three important effects of the Green Tripartite Agreement are worth highlighting in relation to methane. First, the agreement will lead to increased rewetting of carbon-rich peatlands, which will lead to increased methane emissions. However, the overall climate effect of rewetting will be positive. Secondly, a subsidy for the feed additive Bovaer will be introduced from 2025, resulting in an estimated methane reduction from feed additives of 0.4 million tonnes annually between 2025 and 2030[40]. Thereafter, the marginal tax rate will exceed the cost of the feed additive, which is why the effect of Bovaer is not estimated from 2030 onwards. When the estimated effect of Bovaer is included in the total methane reduction calculations, the use of feed additives could result in a reduction of up to 5 percentage points. Thirdly, the agreement is expected to lead to a reduction in livestock numbers (which will have the largest impact on methane reductions in the agricultural sector). How much livestock numbers will be reduced and what the associated effect will be is highly uncertain. In conclusion, Green Transition Denmark does not expect the effects of the Tripartite agreement to reduce methane emissions sufficiently and remain skeptical of potential negative side-effects of Bovaer.

'The Climate Status and Projection' accounts for methane emissions in CO2e based on the global warming potential over 100 years (GWP100). If Danish methane emissions were instead calculated in terms of their 20-year global warming potential (GWP20), the climate impact would be three times higher, and so would expected-reductions. A 30% reduction of methane emissions from 2020 to 2030 (in line with the GMP) measured based on GWP20, would thereby result in a reduction of 8 million tons CO2e[41]. A 40-45% reduction, which is needed to honor the Paris Agreement, would result in reductions of 10.7-12 million tons CO2e.

Table 1: Projection of the Change in Danish Methane Emissions from 2020-2030[42]
(Mio. Ton Co2e based on GWP100)

Sectors	2020	2030	% reduction from 2020 to 2030*
Energy	0.37	0.25	-32 %
Agriculture	7.28	5.96	-18 %
LULUCF	0.3	0.51	70 %
Waste	0.96	1.34**	40 %***
Total	8.91	8.06	-10 %
Total with partial correction regarding methane leakage from biogas production	8.91	7.53	-15 %

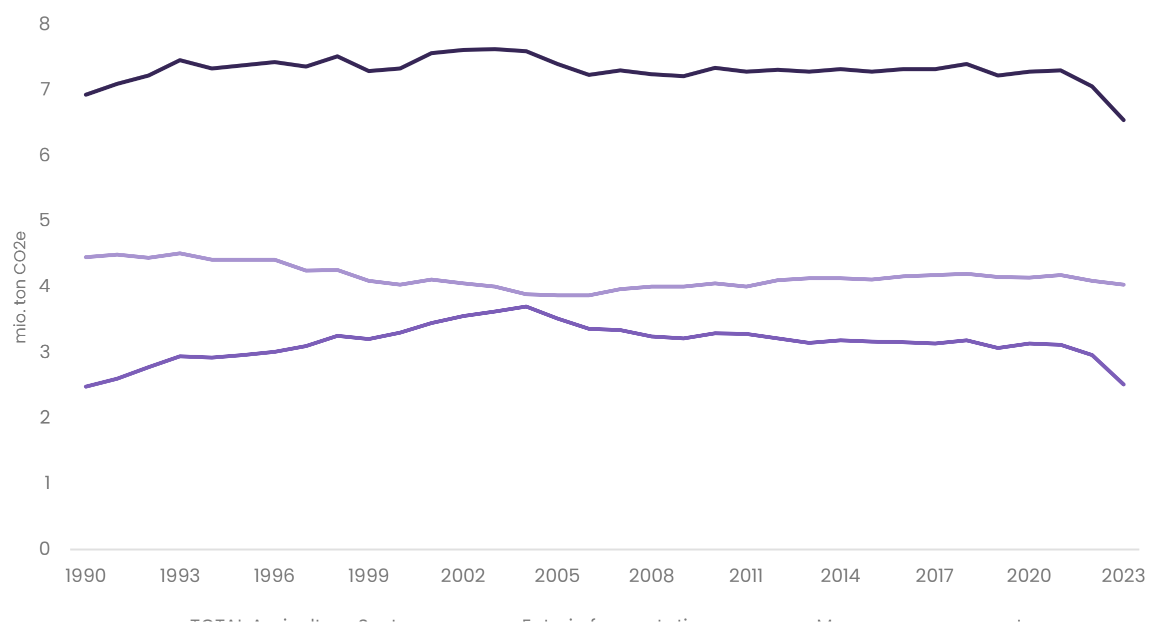
* If the estimated effect of the feed additive Bovaer is included, the number for agriculture in 2030 is 5.56 and methane emissions would be reduced by up to 5 percentage points. This results in a total reduction of 15-20%.
** If the correction regarding methane leakage from biogas production is included, the number will be 0,81
*** If the correction regarding methane leakage from biogas production is included, methane emissions from the waste sector decrease by 16%

Agriculture Sector

The agriculture sector is the main contributor to Danish methane emissions, with livestock accounting for almost all methane emissions. Methane emissions from livestock stem from enteric fermentation, which is the digestive process in the rumen of ruminant animals, and manure management, the methods used to handle animal manure. The development in the agriculture sector has been fairly stable since 1990, but the Danish climate projections predict that methane emissions from agriculture will decrease by 18% in 2030 compared to 2020. The projected decrease in methane emissions is mainly due to an expected decrease in the number of dairy cows and pigs, increased biogasification of cattle and pig manure, the implementation of requirements for frequent sluicing in pigsties from 2023, and the extraction and extensification of agricultural land to reduce fertiliser use[43]. It is important to mention that there is a great uncertainty in the projections and measurements of methane emissions in the agriculture sector because it is difficult to quantify the complex biological processes.

As in other EU Member States, the Danish agricultural sector is heavily dependent on the support it receives from the European Union's Common Agricultural Policy (CAP). However, a study of the CAP shows that 82% of the EU's agricultural subsidies are allocated to animal-based food (38% directly and 44% for animal feed)[44]. This is because the subsidy system is based on support per hectare, which means that farms that use more land receive more money. One of the main reasons why animal production receives the largest share of agricultural subsidies is that it takes up a lot of land to grow feed for animals. The CAP architecture favors animal production and makes it difficult to transform food production into more sustainable and plant-based production. However, an agriculture sector with less livestock and more plant-based production would massively reduce methane emissions from the sector.

Figure 10: Development of Danish Methane Emissions in the Agriculture Sector[45]

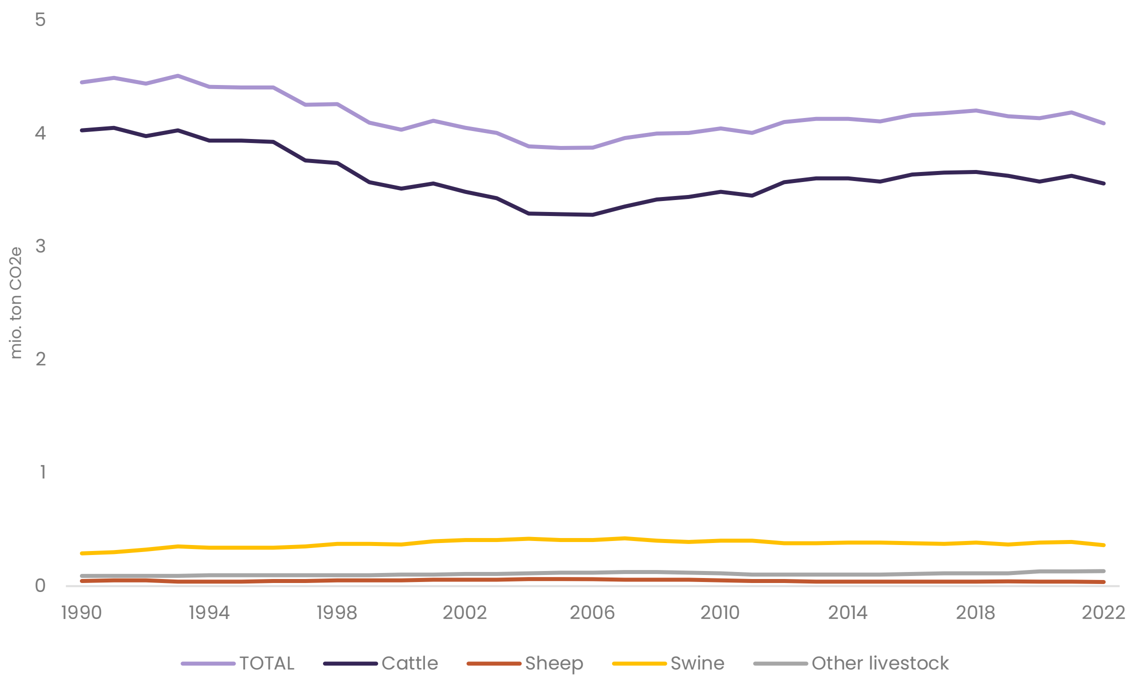


Enteric Fermentation

In 2023, enteric fermentation accounted for 62% of methane emissions from livestock[46]. The metabolism of feed in the rumen of ruminants leads to the formation of methane. Methane emissions from enteric fermentation in ruminants with a multi-chambered stomach, particularly dairy cows, are significantly higher than emissions from production animals with a single stomach, such as pigs[47]. This is clearly illustrated in Figure 11, which shows that cattle are responsible for the vast majority of methane emissions from enteric fermentation.

Methane emissions from enteric fermentation can be influenced by feeding practices and breeding and, most importantly, by the number of ruminants. The Danish government is adopting a requirement to reduce emissions from livestock digestion that includes the use of fodder with a high content of fat from 2025, which can reduce methane emissions from dairy cows. Nevertheless, methane emissions per dairy cow are expected to increase due to genetic improvement, increased feed intake and optimised feed composition in relation to production[48]. The expected decrease in methane emissions from enteric fermentation is therefore primarily driven by an expected decrease in the number of dairy cows in Denmark.

Figure 11: Development of Methane Emissions from Enteric Fermentation[49]



Feed additives and optimization are not enough

In the Danish debate on how to manage methane emissions from the enteric fermentation of cows, the feed additive 'Bovaer' is highlighted. This is because it is estimated to reduce methane emissions from dairy cows by around 30%. The effect of Bovaer is not included in the ministry's Climate Status and Projections 2024, but it is expected to be included in the Climate Status and Projections in 2025 if the climate effect is consolidated[50]. It is important that the trade-offs of technologies are well thought through before they are implemented on a large scale.

In the case of Bovaer, the effect of the feed additive on animal welfare has not been studied in-depth and studies show that cows with high doses of Bovaer in their feed eat less, which may be because the feed additive causes discomfort to the cow[51]. At the same time, the use of Bovaer risks keeping cows in barns with no or limited grazing time that otherwise could have increased biodiversity and nutrient cycling. Meanwhile, studies from the Netherlands[52] and Sweden[53] show that methane emissions from cattle can be reduced by approximately 30% if the animals only graze fresh grass and are not kept and fed in barns. A Danish research project called MetGraz is also investigating whether grazing cows emit less methane than cows in barns, and preliminary results show that this is the case[54].

The trade-offs and side-effects of feed additives, as well as other measures to optimize feed, need to be considered. For example, palm oil is being used to increase the fat content in cow feed, but this causes deforestation in other parts of the world. As a result, national emissions might drop, while they will rise elsewhere, limiting net effect significantly – or removing it entirely[55]. Therefore, feed optimization must consider the global net effect as well as animal welfare concerns. An alternative here could be Danish grown rapeseed, which only has a third of the climate impact of imported palm oil.

Overall, to properly address methane emissions from enteric fermentation, feed additives and feed optimization are important tools, but they are not enough. A structural transformation of agriculture away from industrial animal production towards plant-based food production is necessary to limit the contribution to global warming and ensure food production within planetary boundaries. The total number of cows needs to be reduced, as this will have a much larger impact on the total methane emissions, and it will free up land for other uses that previously was used for fodder.

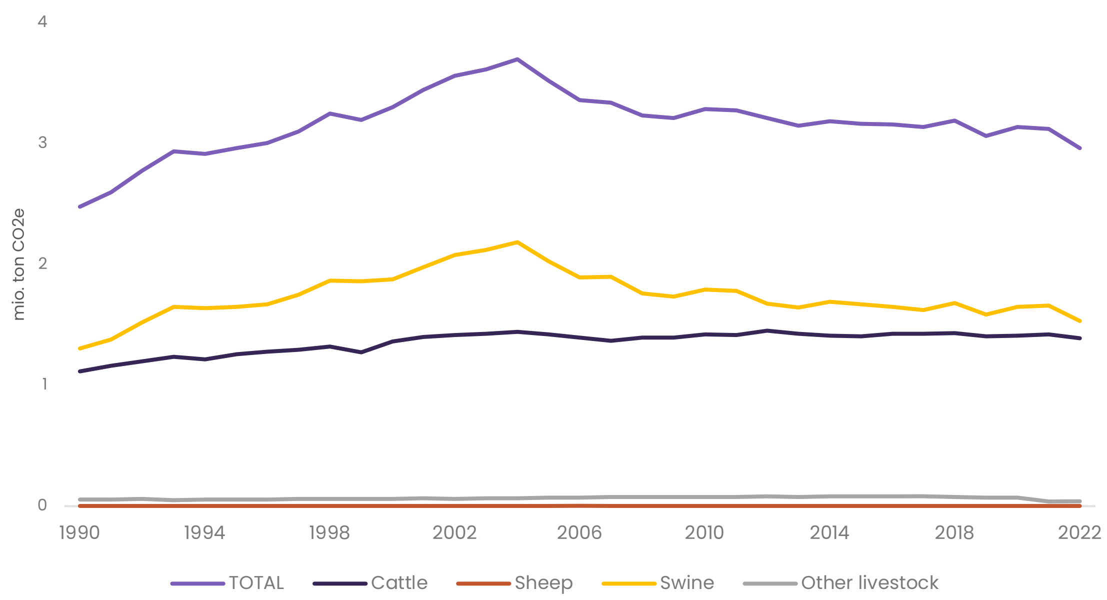
Manure Management

Methane emissions from manure management accounted for 38% of methane emissions from agriculture in 2023[56]. Methane and nitrous oxides are produced when manure is stored in barns and storage facilities, but emissions vary depending on the amount and type of manure and can be influenced by the way manure is managed and stored in livestock buildings and slurry tanks[57]. Especially cooling, acidification, and biogasification reduces methane emissions.

Figure 12 illustrates that manure management in pig production accounts for most methane emissions from manure management, followed by cattle production[58]. While methane emissions from manure management in pig production have decreased since they peaked in 2004, manure management in cattle production have increased slightly since 1990, but remained more or less stable since 2012, which is why the two types of productions soon emit the same amount of methane. In 2030, methane emissions from manure management of pig and cattle production are expected to be the same[59].

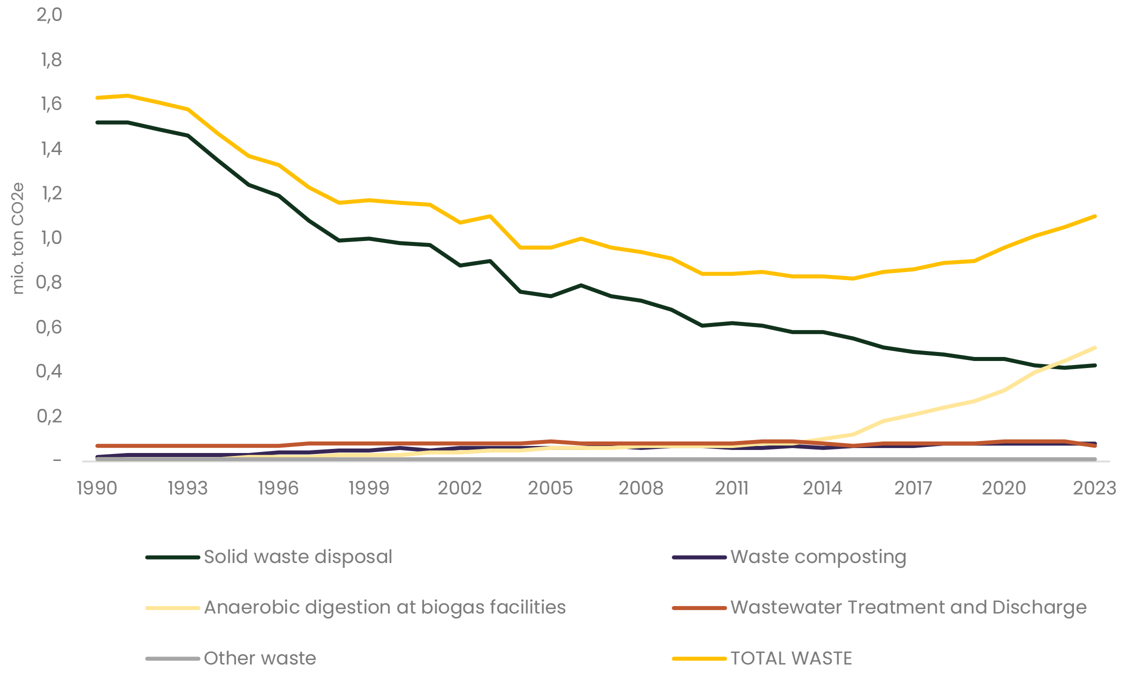
Methane emissions from manure management can be influenced by storage time, temperature, and manure treatment technologies (e.g. biogas plants, more frequent sluicing or slurry cooling)[60]. The projected reduction in methane emissions from manure management is expected to be driven by the requirement of frequent sluicing in pigsties, by extensification of agricultural land, which reduces the use of manure, and by increased biogasification[61] of cattle and pig manure. These technologies are important in reducing methane emissions from the agricultural sector, but it is questionable whether technology alone can ensure that we meet our climate targets. The unsustainable scale of livestock production needs to be addressed if the targets are to be met.

Figure 12: Development of Methane Emissions from Manure Management[62]



Waste Sector

Figure 13: Development of Danish Methane Emissions in the Waste Sector[63]



In the waste sector, the two main sources of methane emissions are solid waste disposal and anaerobic digestion at biogas facilities. In 2023, solid waste disposal accounted for 39% of methane emissions from the waste sector, while anaerobic digestion at biogas facilities accounted for 46%[64]. The remaining 15% came from composting (7%), anaerobic digestion at wastewater facilities (3%), septic tanks (3%), sewage systems (1%), and other waste (1%). Methane emissions from the waste sector are expected to increase in the future, mainly due to an increase in biogas production, which leads to an increase in total methane emissions from anaerobic digestion[65]. However, if the expected effect of the earlier-mentioned regulation (see page 12) on methane leakage from biogas facilities, which was adopted in 2022, is included, the overall methane emissions from the waste sector will be reduced.

Anaerobic Digestion at Biogas Plants

Biogas plants use the process of anaerobic digestion, where organic material (such as livestock manure) is broken down by bacteria in an oxygen-free environment, to produce biogas, which is a mix of mainly methane (CH_4) and carbon dioxide (CO_2). The production of biogas is a source of methane emissions due to leaks in the processing plant and from the upgrading process, which separates CH_4 from CO_2. In the future, biogas production is expected to increase, leading to potentially higher emissions from methane leakage. At the same time, the above-mentioned new regulation on methane leakage from biogas facilities, which requires biogas facilities to minimise their methane leakage to less than 1%, which is expected to reduce emissions. If this succeeds, emissions from methane leakage from biogas facilities will decrease despite increased biogas production[66]. However, the methane leakages are not expected to be quantified until 2025, and there is still much uncertainty about the effects of the regulation.

Green Transition Denmark recommends close monitoring of the new methane leakage regulation since additional measures must be taken if a leakage of less than 1% seems unfeasible with the current regulatory setup. Also, quantifying methane leakage better will provide more accurate greenhouse gas accounting.

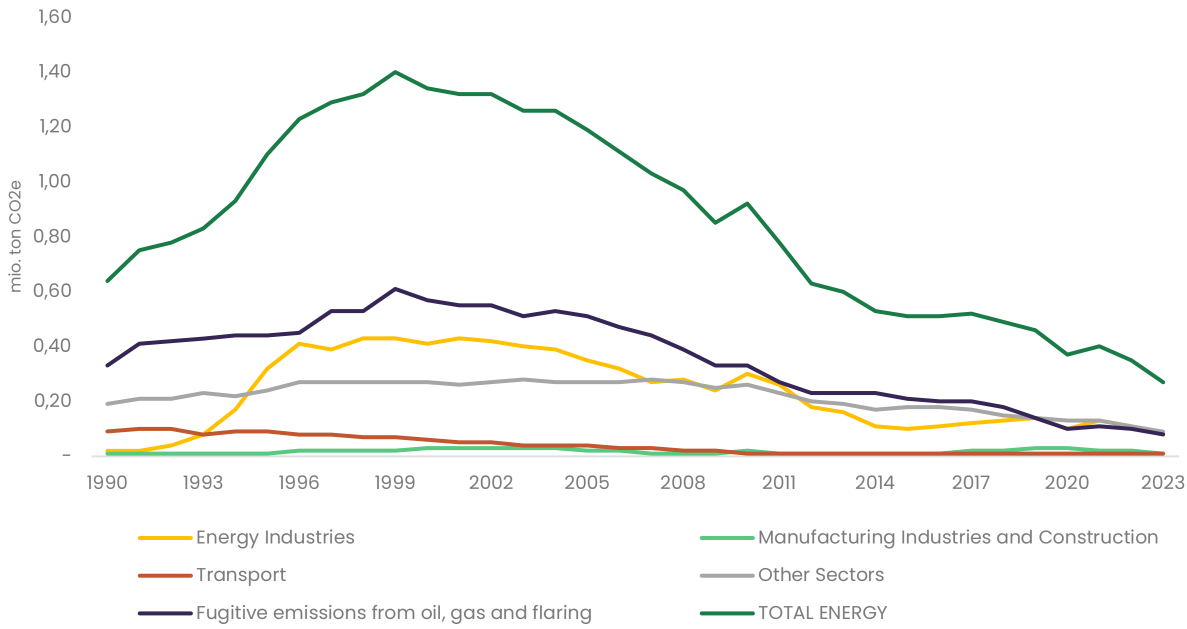
In addition, Green Transition Denmark recommends that the government lays out a strategy for expanding biogas production targeted towards plant-based biomass, e.g. side streams from industry, farms and household waste, rather than manure. Since we need to reduce livestock numbers, we must not create a lock-in to a certain livestock production size by investing intensely in manure-based biogas plants. The production of biogas in Denmark is projected to increase from 22 PJ in 2022 to about 50 PJ in 2035[67]. Calculations from EA Energy made on request of Greenpeace, show that it is possible to produce 50 PJ biogas in Denmark while simultaneously reducing the number of livestock by 50%[68]. In addition, a report from Green Transition Denmark shows that it is possible to phase out the use of fossil energy by 2040 with the use of only 42,3 PJ of biogas[69].

Solid Waste Disposal

When organic waste deposited in e.g. landfills is broken down by bacteria in an oxygen-free environment (the process of anaerobic digestion mentioned above), methane is produced. Methane emissions from landfills have decreased significantly since 1990 because the amount of organic waste going to landfills has decreased over time, while organic waste in landfills naturally degasses over time. One reason for the reduction in the amount of organic waste going to landfill is the partial ban on landfilling of organic waste introduced in 1997, which means that most organic waste is now treated by composting, incineration or biogasification[70]. However, the decrease in emissions has stagnated in recent years and is expected to remain at about the same level. One of the reasons for this development is that the amount of waste is expected to increase and that the disposed waste degasses over time, according to the Climate Projection[71].

Energy Sector

Figure 14: Development of the Danish Methane Emissions in the Energy Sector[72]



In the energy sector, the three main sources of methane emissions are currently 'fugitive emissions from fuels', 'energy industries' and 'other sectors'. In 2023, fugitive emissions from extraction and distribution of fuels accounted for 30%, energy industries for 30%, and other sectors for 33%[73]. Methane emissions from the energy sector are projected to decrease overall towards 2030, due to reductions in methane emissions from public electricity and heat supply, cars and residential buildings. However, fugitive emissions from gas are projected to increase towards 2030, accounting for 48% of methane emissions from the energy sector in 2030[74].

Energy Industries and Other Sectors

Methane emissions from energy industries, which in the Danish case is 'public electricity and heat production', are expected to decrease towards 2030. One of the targets of the Climate Agreement on green power and heat from 2022 is that all gas in Denmark should be green by 2030, which means that district heating companies are required to plan for the phasing out of fossil natural gas in the heat production[75]. However, this green gas target is defined as being achieved when the production of biogas is higher than the Danish consumption of piped gas, even though fossil natural gas will still flow through the Danish gas system, as it is part of the European gas network[76]. Denmark should therefore replace the use of gas where alternatives exist, e.g. electrification, even if the gas in the pipelines is green gas in terms of inventory. A possible surplus of Danish biogas could then be exported via the European gas network to other countries where biogas will replace the use of fossil natural gas - e.g. in Germany.

Other sectors that are responsible for methane emissions within the energy sector are 'residentials' and 'agriculture, forestry and aquaculture'. While methane emissions from 'agriculture, forestry and aquaculture' are expected to remain the same towards 2030, the emissions from 'residentials' are expected to decrease. Gas boilers in households are an emitter of methane within this category. The above-mentioned Climate Agreement from 2022 also sets the target that no residential buildings should be heated with gas by 2035[77]. In 2023, 380.000 households were estimated to use a gas boiler as primary heating system, and this number is estimated to decrease to 130.000 in 2030 and to 110.000 in 2035[78]. This means that the target of no gas heated residential buildings in 2035 will not be achieved.

Gas in the heating sector should be phased out

In 2022, after the war broke out in Ukraine, the government tried to step up its efforts to meet the target of no gas heated residential buildings. The government asked municipalities to inform owners of gas boilers within a year whether they would be offered district heating before 2028, and at the same time funding schemes for heat pumps in residential buildings were set up to encourage those who would not be offered district heating to invest in heat pumps instead. But this attempt was not successful, as the municipalities were not able to complete the planning of the district heating pipelines within the timeframe.

Despite the unsuccessful attempt, methane emissions are projected to decrease due to an expected decrease in consumption of piped gas, biogas and fossil natural gas, as gas boilers are replaced by heat pumps or district heating, and due to an expected increase in the share of biogas in piped gas[79]. The same development is estimated to apply for the gas used for space heating in businesses.

Green Transition Denmark recommends that the use of gas in the heating sector should be phased out by 2030 at the latest. This can be done by directing more planning resources to municipalities. This will allow them to map out whether owners of gas boilers will have access to district heating or whether they will need to invest in heat pumps.

In order to achieve the aforementioned goal of 100% green gas in the Danish gas pipeline system, we must not only expand biogas production, but also reduce gas consumption overall. Biogas production must not be expanded more than it is still possible to significantly reduce the number of livestock animals to a sustainable level, and we must continue to phase out the use of energy crops in biogas plants[80]. Biogas should only be used where there are no good alternatives, i.e. in certain industries where high temperatures are required and for peak loads in productions. This also means that biogas should not be used in the heating sector, where better alternatives are available.

In order to phase out gas heating in Danish households, we also need a ban on the installation of new gas boilers for heating. If this should be seen as violating EU single market regulation, Denmark could instead put a high tax on new gas boilers. When gas boilers are taken out, while the owners are waiting for district heating pipes in their local area, the utility company must provide them with an intermediate solution, a second-hand boiler or an intermediate heat pump solution.

Fugitive Emissions

Fugitive emissions from fuels and flaring are methane leaks that occur during the extraction, production, processing, storage, transmission and distribution of oil and gas products[81]. In Denmark, the greatest contributors of fugitive methane emissions are the platforms in the North Sea that extracts oil and gas, as well as refineries[82]. Fugitive emissions from oil and from flaring (controlled burning of excess methane from oil and gas production and refining) is projected to remain the same towards 2030, while fugitive emissions from gas are projected to increase[83].

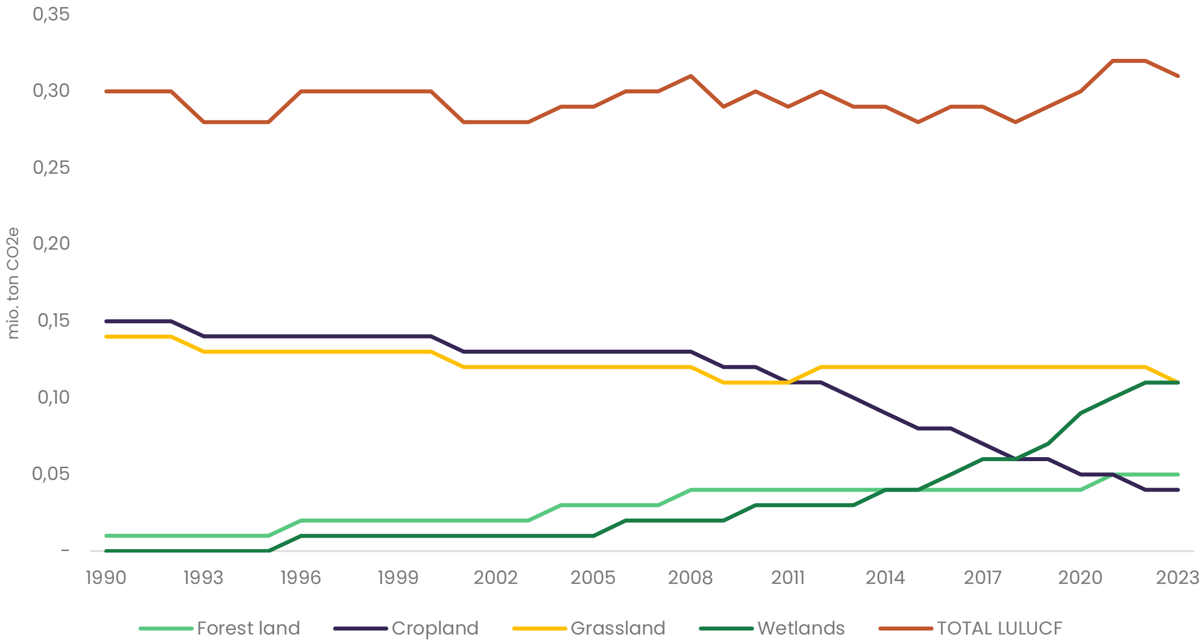
Green Transition Denmark recommends that instead of putting effort and resources into fixing pipes, which has a smaller impact on methane emissions from oil, fossil natural gas and energy production in general, effort and resources should be put into the goal of phasing out the production of oil and fossil natural gas. We can fix pipes as an urgent measure to tackle fugitive methane emissions, but this needs to be complemented by an end date for the use of oil and gas. Green Transition Denmark has presented a transformation scenario which shows that it is possible to phase-out fossil energy in all parts of society by 2040[84]. The scenario shows that it is possible and economically responsible.

Land Use, Land Use Change and Forestry (LULUCF)

In the Land Use, Land Use Change, and Forestry (LULUCF) sector 'grassland' and 'wetlands' currently accounts for most methane emissions. In 2023, grasslands and wetlands each accounted for 35% of the sector's methane emissions, while forest land and cropland accounted for 16% and 13% respectively[85]. While methane emissions from grassland, forest land, and cropland decrease towards 2030, emissions from wetlands increase. This means that wetlands are projected to account for 73% of LULUCF's methane emissions in 2030. The implementation of policies that facilitate the set-aside and rewetting of carbon-rich agricultural land for the purpose of wetland restoration is expected to result in a significant increase in the number of wetlands[86].

As mentioned earlier, methane emissions from wetlands are defined as a natural source of emissions, and wetlands also make a positive contribution by acting as carbon sinks, regulating the water cycle and supporting biodiversity. Furthermore, when peatlands are drained for agriculture purposes, they emit large amounts of CO_2. Rewetting will therefore lead to a net reduction in greenhouse gas emissions of 10-40 tons of CO_2e per hectare rewetted per year[87]. Therefore, increasing methane emissions from this land use is not alarming.

Figure 15: Development of the Danish Methane Emissions in the LULUCF sector[88]



Conclusions

This paper has examined Danish methane emissions, what the sources of methane emissions are, in which sectors they are located, and how they are projected to develop towards 2030. Table 2 shows which sources account for the majority of methane emissions in Denmark in 2020 and their projections to 2030. As shown in this table, it is enteric fermentation and manure management in the agriculture sector that account for the vast majority of Danish methane emissions, should therefore also be further addressed.

Therefore, the main focus must be on how to reduce emissions from this sector. It is also important to address methane emissions from the other sectors, where reduction measures are available at a low or negative cost. Biogas leakage in the waste sector and phasing out oil and gas in the energy sector, including accelerating phasing out gas boilers in Danish households

Table 2: The Largest Sources of Methane Emissions in Denmark*[89]
(% of total methane emissions)

		% in 2020	% in 2030	% in 2030 with methane leakage from biogas production correction
Energy Sector	Fugitive emissions from gas	1 %	1 %	2 %
Agriculture Sector	Enteric fermentation	46 %	48 %	51 %
	Manure management	35 %	26 %	28 %
LULUCF Sector	Wetlands	1 %	5 %	5 %
Waste Sector	Solid waste disposal	5 %	5 %	5 %
	Anaerobic digestion at biogas facilities	4 %	9 %	3 %**

*Methane emissions that account for under 2% is removed from this table
**Methane leakage from biogas production is subtracted here.

Green Transition Denmark's 9 Recommendations Elaborated

1. **Develop a National Methane Action Plan with a Reduction Target of 40-45%**

   Denmark must develop a National Methane Action Plan as soon as possible, with an ambitious target of 40-45% by 2030 compared to 2020. This reduction target is considered cost-effective and feasible in the Global Methane Assessment. And it is necessary because global warming is approaching 1.5°C and methane emissions, with their high short-term global warming potential (GWP), will have a major impact on whether we can keep the temperature below 1.5°C.

2. **Incorporate the Short-term Perspective (GWP20) in the Decision-making**

   The short-term perspective (GWP20) must be included in the plan of reaching the Danish climate goal, as the deadline is within the next 20-25 years. Here reductions of methane emissions play a particular important role. A 30% reduction of methane emissions in 2030 compared to 2020 measured based on GWP100 will result in a reduction of 2.7 million tons of CO_2e, but if the reduction is measured based on GWP20 the same 30% reduction will result in a reduction of 8 million tons of CO_2e. The use of GWP20 takes into account the disproportionate impact of methane on short-term temperature and gives policymakers an incentive to focus on reducing methane emissions to deliver immediate climate benefits, slowing the rate of global warming and buying time for longer-term CO_2 mitigation strategies.

3. **Transition from Animal Production to Plant-based Food Production**

   The size of the Danish livestock production needs to be reduced significantly as it accounts for the vast majority of Danish methane emissions. Transitioning to plant-based food production systems will enable Denmark to become a net producer of proteins[90]. Reducing livestock production not only benefits the climate by reducing methane emissions, but it also has a number of other positive side-effects. To name just a few, a reduction in livestock will lead to a reduction in soybean imports, thereby contributing positively to land use change elsewhere in the world. The reduction will also contribute positively to Danish land use, as almost 80% of agricultural land is used to grow animal feed[91].

4. **Consider the Trade-offs of the Use of Technologies Before They are Implemented**

   Some technologies can help reduce methane emissions, but it is important to thoroughly consider potential negative trade-offs. These should be properly assessed before such technologies are subsidized or implemented through regulation. An example of this is the feed additive Bovaer or the use of palm oil in feed, as described above. The money invested in technologies that lock-in current industrial livestock production and leads to deforestation and animal welfare issues, can be used better. For example on documenting the potential effect of grazing, which carries positive side-effects.

5. **Phase Out the Use and Production of Oil and Gas**

   Production of oil and fossil natural gas must be phased out as soon as possible. We might repair pipes as an urgent way of dealing with fugitive methane emissions from production, but this needs to be complemented by an end date for the use of oil and gas. It is possible to achieve a phase-out in 2040, which will have a significant impact on reducing methane emissions from the energy sector.

6. **Advance the Target of a Phase-out of the Use of Gas Boilers in Danish Households**

   Denmark must phase out gas (fossil natural gas and biogas) for household heating by 2030. Municipalities need more planning resources to meet the 'Climate Agreement on Green Power and Heat,' which aims to implement district heating by 2028, providing a better alternative to gas boilers in all households. To support this, a ban on the purchase of gas boilers should be introduced in 2025, as they typically last about 20 years. Given Denmark's goal of climate neutrality by 2045, citizens should avoid investing in gas boilers from 2025 to facilitate the transition away from gas heating.

7. **Biogas Production and Use must be Sustainable**

   Biogas is an important tool for addressing climate, water and waste problems together, but the production must be sustainable. This means that the expansion of biogas production must be in accordance with the need to reduce livestock numbers significantly.

8. **Biogas Should Only be Used Where There are No Better Alternatives**

   The use of biogas must be prioritized for areas where there are no alternatives, e.g. certain industries that require high temperatures and for peak load in the production. We need to use biogas wisely so that it effectively replaces the use of fossil natural gas. This means that it should not be used in the heating sector where alternatives are available.

9. **Methane Leakage from Biogas Plants Must be Addressed**

   Methane leakage from biogas plants must be addressed to minimize emissions. The reduction effect of the new methane regulation needs to be closely monitored, as additional measures will need to be taken if leakage of less than 1% seems unachievable under the current regulatory regime. In addition, the quantification of methane leakage needs to be improved to enable more accurate greenhouse gas accounting.

Read more

Methane Matters:
https://methanematters.eu/

Energy within Planetary Boundaries:
https://rgo.dk/en/energi-inden-for-planetaere-graenser/

From Feed to Food II:
https://rgo.dk/en/publication/from-feed-to-feed-in-report/

Green Transition Denmark Methane Matters

This report has been made with funding from the Methane Matters Coalition. Green Transition Denmark is a partner organisation of the Coalition.

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61. Biogas treatment of cattle and pig manure leads to lower methane emissions from the manure storage due to an often shorter storage time before collection, and due to the emissions from the returned biogasified manure are very low compared to non-biogasified manure https://www.kefm.dk/Media/638500583839358855/KF24%20Kapitel%2017%20Landbrugsprocesser.pdf
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80. From July 2024 maximum 4 % (by weight) of the feedstock to biogas plants can be energy crops (like maize, beet, grain, and grass) and from 2025 it will no longer be permitted to use maize in biogas production - https://ens.dk/ansvarsomraader/bioenergi/energiafgroeder-til-biogas
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90. At present, Denmark produces protein for about 16 mio. people annually, but imports protein equivalent to the protein requirements of 23 mio. people. The current protein balance is therefore negative. Source: https://okologi.dk/media/owkjpddm/fftf2.pdf
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