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SUMMARY AND RECOMMENDATIONS

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This report from the Chairmen of the Danish Economic Council of Environmental Economics contains three chapters that focus on Danish climate policy. There are three main conclusions:

It is an economically manageable task to attain the objective of reducing greenhouse gas emissions by 39 per cent by 2030 in those sectors that are not part of the EU ETS (emissions trading system). In fact, it may be beneficial to reduce emissions, if it is done cost efficiently.

The costs of reducing emissions from agriculture are low, while reducing emissions from passenger cars is associated with high costs. This reflects the high initial tax burden on passenger cars.

The recent agreement regarding changes to the EU ETS is found to result in a reduction in greenhouse gas emissions. While this is beneficial, the agreement also increases uncertainty about the global effects of Danish measures. This makes it more complex to design a Danish climate policy that contributes to lower global emissions.

ENGLISH SUMMARY

This present report from the Chairmen of the Danish Economic Council of Environmental Economics consists of three chapters:

- Regulation of agricultural emissions of greenhouse gases
- Reducing CO_2 from passenger cars
- Climate policy towards 2030

The first two chapters contain estimates of the costs of reducing greenhouse gas emissions from agriculture and passenger cars. These estimates are used in the third chapter, which contains an overall assessment of the costs of reducing greenhouse gas emissions in the non-ETS sectors by 2030.[1] The third chapter also includes an analysis of the consequences of Danish initiatives in the ETS-sector when the new reform of the EU ETS is taken into account.

REDUCTION OF GREENHOUSE GAS EMISSIONS IN NON-ETS SECTORS

Denmark must reduce emissions of greenhouse gases in non-ETS sectors by 39 per cent by 2030, compared to 2005. In 2015 agriculture and passenger cars accounted for, respectively, 31 and 21 per cent of total Danish emissions in non-ETS sectors.[2] The remaining non-ETS sectors include, e.g., residential heating, industry and services not covered by the EU ETS and heavy transport (goods transport and buses).

Based on the Danish Energy Agency's 2017 emissions projection it is estimated that in 2030 emission reductions of 2.5 million tonnes will be required in order to reach the target reduction of 39 per cent,

1) The EU groups emissions into three categories: emissions from installations covered by the ETS (emissions trading system), emissions covered by the effort sharing regulation and emissions from the land use, land use change and forestry (LULUCF) sector. In the following, non-ETS refers to emissions covered by the effort sharing regulation, but not emissions from LULUCF.

2) CO_2e is used to denote the emission of all greenhouse gases (including agricultural emissions of methane and nitrous oxide), converted to CO_2-equivalents.

compared to 2005. The analysis in this report is based on this reduction requirement.[3]

The reduction requirement of 2.5 million tonnes of CO_2e in 2030 must be attained through emission reductions in the non-ETS sectors. However, Denmark can also cancel allowances from the EU ETS amounting to 0.8 million tonnes yearly. These cancellations can count towards fulfilling the reduction requirement (one of the so-called flexibilities).

The analysis indicates that it is economically manageable to attain the emissions reduction of 2.5 million tonnes in 2030. However, the cost for society greatly depends on how the reductions are achieved.

If, for instance, policy is designed such that all non-ETS sectors contribute the same share of emission reductions compared to their current share of emissions, the cost for society is relatively high. In this case, the total cost amounts to DKK 0.8 billion for the year 2030, see table A. This reflects that emission reductions from passenger cars are relatively expensive compared to the cost of emission reductions in the agricultural sector and in the remaining non-ETS sectors.

A benefit for society of DKK 0.4 billion could be achieved if reductions were designed cost efficiently instead. This benefit reflects, among other things, co-benefits from reduced emissions of nitrogen and ammonia in agriculture. The analysis shows that the agricultural sector would account for 37 per cent of all emission reductions if reductions were split cost efficiently among the sectors. Cost efficiency also implies that emissions from passenger cars should not be reduced.

Greenhouse gas emissions from agriculture are not currently directly regulated. The benefit would be reduced to DKK 0.1 billion if the agricultural sector remains exempt from regulation in the future. This corresponds to a yearly cost of DKK 0.3 billion. The cost of exempting the agricultural sector depends on the greenhouse gas reduction requirement. If, for instance, the total reduction requirement in 2030 turns out to be 4 million tonnes instead of 2.5 million tonnes, the costs of exempting the agricultural sector rises to DKK 2.5 billion per year.

3) The reduction target of 39 per cent is implemented as yearly emission ceilings for each year in the period 2021-30. Compared to projected emissions in the absence of additional initiatives, emissions must be reduced by a total of approximately 13 million tonnes over the entire period. The focus of the report is on the year 2030, where it is estimated that emissions must be reduced by 2.5 million tonnes to comply with the total reduction requirement. The total reduction requirement depends on economic growth and technological development, among other things. The reduction requirement may, therefore, turn out to be larger or smaller.

TABLE A COSTS OF A 2.5 MILLION TONNE REDUCTION IN 2030

Type of reduction	Share of total reductions				Total cost
	Agriculture	Passenger cars	Remaining	Allowances	
	---------- Per cent ----------				Bn. DKK
Proportional efforts	31	21	48	•	**0.8**
Cost efficient	37	0	49	14	**-0.4**
Exempting agriculture	•	0	68	32	**-0.1**

Note: The table shows the cost (2017 prices) of a reduction of 2.5 million tonnes of CO_2e in the non-ETS sectors, compared to the projected emissions in 2030. The column "allowances" is use of the allowance cancellation flexibility, where Denmark can make use of a yearly maximum of 0.8 m. tonnes.

Source: Own calculations based on chapters I (agriculture) and II (passenger cars) as well as Dansk Energi (2017) and Klimarådet (2017).

NEW ASSESSMENTS FOR AGRICULTURE AND PASSENGER CARS

The assessments of the social costs and benefits of reducing greenhouse gas emissions from the Danish non-ETS sectors in 2030 are based on new empirical analyses of the cost of reducing emissions from agriculture and privately owned passenger cars.

The analysis of the agricultural sector is based on the ESMERALDA model. The analysis examines the economic and environmental consequences of applying a tax to greenhouse gas generating activities within the sector, including animal husbandry, fertilizer usage and crop cultivation. Introducing an indirect carbon tax would lead to a reorganization of the sector, as the returns to farming would be reduced. The resulting loss of profits constitutes part of the marginal abatement cost of reducing greenhouse gas emissions from agriculture.

The cost of reducing carbon emissions from passenger cars is examined using a new model for car ownership, kilometres travelled and fuel consumption for Danish households. The cost of reducing an additional tonne of CO_2 is explored in the model through a gradual increase in the existing fuel tax. Households can adapt to higher fuel taxes by driving less, switching to more fuel-efficient cars or to electric cars, or by exiting the car market altogether These choices are associated with a welfare loss for car owners, which constitutes the

major component of the marginal abatement costs from passenger cars.

A number of co-benefits result from the reduction of greenhouse gas emissions from agriculture and passenger cars. In the agricultural sector these include reduced leaching of nitrogen to the aquatic environment as well as lowered ammonia emissions. For passenger cars, co-benefits encompass reductions in congestion, road accidents and noise pollution. These benefits partly offset the marginal abatement costs in the two sectors. The starting point for both analyses is a baseline scenario characterized by frozen policy towards 2030.

The costs of reducing greenhouse gas emissions from agriculture, passenger cars and the remaining parts of the non-ETS sector in 2030 are presented in figure A. It is evident from the figure that reducing CO_2 emissions from passenger cars is relatively expensive, as marginal abatement costs start at DKK 2,000 per tonne and increase for larger abatements. In contrast, there is a social benefit associated with reducing greenhouse gas emissions from the remaining parts of the non-ETS sector. Negative marginal abatement costs for agriculture are found up to a reduction of 0.8 m tonnes CO_2e.

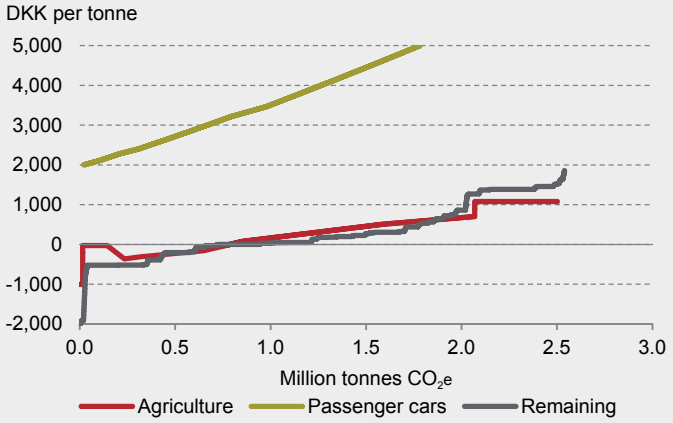
The net benefit of reducing emissions from the agricultural sector reflects that the loss to farmers from lower production is more than offset by the environmental co-benefits related to reduced emissions of nitrogen and ammonia.

The marginal abatement costs in the remaining non-ETS sectors also seem to be relatively low. The curve in figure A is based on two Danish studies. It indicates that up to a certain point the co-benefits of reducing greenhouse gas emissions from these sub-sectors offset the costs, which leads to a net benefit of reducing greenhouse gas emissions.

A cost-effective fulfilment of the total reduction requirement for the non-ETS sector can be achieved by imposing a uniform carbon tax across all sub-sectors. If there are co-benefits that are inadequately regulated, there can, however, be a case for deviating from the principle of uniformity. The direct regulation of these co-benefits is preferable to a differentiation of the carbon tax. This topic is revisited later in a discussion in the summary of the joint regulation of greenhouse gases, nitrogen and ammonia emissions from agriculture.

FIGURE A WHAT DOES IT COST TO REDUCE CO_2e EMISSIONS IN NON-ETS SECTORS?

It is expensive to reduce emissions of CO_2e from passenger cars in 2030, compared to agriculture and the remaining non-ETS sectors.



Note: The figure shows the marginal reduction costs per tonne of CO_2e in 2030 in the non-ETS sectors. Remaining non-ETS sectors include e.g. buildings, waste and transportation other than passenger cars.

Source: Own estimations based on chapters I (agriculture) and II (passenger cars) as well as Dansk Energi (2017) and Klimarådet (2017) (remaining non-ETS sectors).

REGULATING CO_2 FROM PASSENGER CARS

An efficient transport system promotes mobility, prosperity, and economic productivity. Transport is, however, also associated with negative impacts including CO_2 emissions, congestion, and accidents, as well as air and noise pollution. These externalities provide a basis for the regulation of transport in the form of, e.g., taxation.

Current tax regulation of passenger cars far exceeds the magnitude of the negative externalities produced. On average, the taxation per kilometre is about twice as high as the social costs resulting from the use of passenger cars, such as accidents, congestion and emissions of CO_2. This suggests that lowering the tax burden on passenger cars in Denmark would be beneficial. The relatively high marginal abatement cost for passenger cars shown in figure A reflects the current tax burden.

The negative externalities from passenger cars are generally a result of either fuel consumption (e.g., CO_2 emissions) or car use (e.g., accidents, noise and congestion). From an economic perspective, taxes should be levied as close to the source of the externality as possible. Hence, the taxation of passenger cars should primarily be concentrated on fuels and vehicle use.

The current Danish taxation of motor vehicles is concentrated on the purchase and ownership of cars, which are not in themselves sources of externalities.[4] Consequently, there is a wedge between what is being taxed (purchase and ownership) and the sources of externalities (fuel consumption and vehicle usage). As a result, the Danish regulation of passenger cars is not targeting the externalities they produce. Such targeting could be achieved by replacing the vehicle registration tax and the green vehicle tax with road pricing while lowering the current tax on fuels.[5] The road pricing scheme should ideally be differentiated with respect to time, place, and type of car, as externalities vary with these factors.

The existing fuel tax represents targeted direct regulation of CO_2 emissions from passenger cars. Additionally, both the vehicle registration tax and the green vehicle tax are also partially differentiated with respect to the fuel efficiency and corresponding CO_2 emissions of vehicles. In consequence, CO_2 emissions from passenger cars are regulated by three different tax instruments, which intuitively seems to be an inefficient regulatory approach.

REGULATION OF THE AGRICULTURAL SECTOR

In Denmark there is currently no direct regulation of the greenhouse gas emissions from the agricultural sector. As mentioned above, this will lead to higher costs of reducing emissions from the non-ETS-sector as a whole.

The most cost efficient regulation of the agricultural sector is direct taxation of actual greenhouse gas emissions. This is, however, not feasible in practice. Instead, the activities causing emissions can be taxed. This includes taxes on livestock units and on fertilizers and the cultivation of crops. The tax rates should correspond to the green-

4) A possible exception concerns the fact that cars take up public space. This externality is regulated in Denmark through the use of parking fees.

5) The registration tax is paid when a vehicle is registered in Denmark and constitutes 85-150 per cent of a vehicle's value. The green vehicle tax is levied bi-annually.

house gas emissions caused by the activities. This would provide the farmers with incentives to reduce greenhouse gas emitting activities or adopt practices with lower emissions.

Greenhouse gas emissions from agriculture can be reduced using various management practices and measures. These include changing animal housing systems, sowing catch crops and the use of slurry acidification. If a farm uses one or more of these measures, the tax on the agricultural activities should systematically be reduced corresponding to the effect on the emissions. This would ensure that farmers have ongoing incentives to continually reduce their greenhouse gas emissions.

Such regulation requires detailed information for each farm about the number of livestock, the type of animal housing system in use and the extent and type of crops cultivated. While this may seem like a large administrative burden for the farmers, they already provide this information in relation to the existing Danish regulation of nitrogen and ammonia. Therefore, the regulation of greenhouse gas emissions could be implemented without placing any further administrative burden on farmers.

Such CO_2 taxes on agriculture would vary widely between different types of farms. Dairy farmers would have to pay relatively high taxes, as cows emit more greenhouse gases than other types of livestock. Any political desire to partially or fully compensate farmers for this loss should be implemented in a way that will not affect the production decisions of the farmers. In practice, this can be done by returning taxes to the farmers according to the emissions just *before* the regulation is introduced. If compensation is granted as a lump sum payment it would ensure that it is fully decoupled from future production choices.

The tax on agricultural activities that emits greenhouse gases can be extended relatively easily to regulate other types of emissions as well. This could, for instance, include regulation of emissions of nitrogen to the aquatic environment or emissions of ammonia. It should be noted that the taxes on emissions of nitrogen, as opposed to emissions of greenhouse gases, would have to vary geographically. However, this would not increase the complexity of the regulation for farmers as there would still be only one tax on each type of activity.

Emission of excess nitrogen from agriculture causes nutrient pollution of the aquatic environment. There are, however, large geographical differences in how much the emissions of nitrogen should be re-

duced. In January 2018 a political agreement was made concerning a new and more targeted regulation of the agricultural emissions of nitrogen in Denmark. The new regulation is based on subsidies for agricultural production that reduce the emissions of nitrogen. One key element of the regulation is to specifically target efforts according to geographic differences. This contrasts with the previous regulation scheme, under which all farmers where required to reduce their emissions by the same amount, regardless of geographical variation in the nitrogen balance.

Despite a more targeted approach, the new subsidy based regulation has some disadvantages. For one, there are no long term incentives to relocate the production with the highest emissions to areas in Denmark where the emissions would cause the least damage to the aquatic environment. This and other disadvantages of the new regulation could be avoided if the regulation instead incurred geographically differentiated taxes on those agricultural activities that emit nitrogen to the aquatic environment. As mentioned, this regulation could be combined with regulation of other types of emissions as well. In the long run this could provide a clearer and more direct common regulation of the various environmental effects of agricultural production.

The activities that cause agricultural emissions of nitrogen and greenhouse gases overlap to a large extent. Therefore, reducing the agricultural emissions of nitrogen would also lead to a reduction in the emissions of greenhouse gases from agriculture. The EU Water Framework Directive has set a target of *good ecological status* for all surface waters and *good status* for groundwater to be achieved no later than 2027. In Denmark this translates into a set of geographically differentiated reduction targets for nitrogen loads to coastal waters and groundwater. The report estimates that, in meeting these nitrogen targets, the agricultural emission of greenhouse gases would be reduced by up to two million tonnes. Fulfilment of the EU Water Framework Directive may, therefore, imply that there is only a modest need for further reductions in the Danish non-ETS sector in order to reach the target of reducing the emissions by 39 per cent by 2030 compared to 2005. Even though the estimate of the effect of fulfilling the Water Framework Directive is quite uncertain, the results illustrate that the level of nitrogen regulation is likely to have a big impact on the total emissions of greenhouse gases.

DENMARK'S OWN TARGET OF 50 PER CENT RENEWABLE ENERGY

In addition to Denmark's EU-obligations, the Danish government has set a national target of 50 per cent of Denmark's energy consumption to come from renewable energy sources (RE) by 2030. This target covers both the EU ETS and non-ETS sectors. Additionally, Denmark is committed to a strategy of being a low emissions society by 2050, according to the so-called climate law (klimaloven). The climate law therefore requires an RE share close to 100 per cent by 2050. The national commitment of 50 per cent RE by 2030 can be considered as a step towards reaching the 2050 goal.

However, targeting a particular RE share by 2030 is not a cost efficient way to reduce emissions of greenhouse gases, since the RE goal does not specifically target reductions in greenhouse gas emissions. Thus, the target for increasing the RE share does not ensure a path of cost efficient reductions in greenhouse gas emissions. One reason for this is that it is possible to increase the RE share without reducing greenhouse gas emissions. Another reason is that the RE target does not take into account agricultural emissions that are not related to energy production.

A body of international literature indicates that additional policy targets increase the cost of reducing greenhouse gas emissions. This is true for RE share targets as well as energy efficiency targets.

If the goal of climate policy is to reduce greenhouse gas emissions in a cost efficient way, it would be beneficial to replace the target for the RE share with a target to reduce greenhouse gas emissions.

THE EU EMISSIONS TRADING SYSTEM AND DANISH CLIMATE POLICY

Theoretically, the most cost effective way to reduce greenhouse gas emissions is to set an international price for these emissions. It is possible to impose such a price through an international tax on greenhouse gas emissions or an international cap-and-trade system. The EU ETS is an example of an international cap-and-trade system. Hence, Denmark should generally ensure that the EU ETS is preserved and made more effective.

Over the last few years a large allowance surplus has accumulated in the EU ETS. The allowance surplus reflects that the politically determined supply of emission allowances substantially exceeds the current demand. As a consequence, the allowance price has been low. Thus the allowance price has provided little incentive to reduce greenhouse gas emissions within the EU ETS. To address the large allowance surplus, the EU introduced the so-called market stability reserve (MSR). Basically, allowances are placed in the MSR if the allowance surplus is large, while allowances are released from the reserve when the allowance surplus is small.

In November 2017 an agreement was reached regarding the next phase of the EU ETS. If the agreement is formally adopted, it might have significant implications for national climate policies in both Denmark and the other EU countries. The new agreement puts a cap on the number of allowances in the MSR. Specifically, allowances within the MSR above the total number of allowances auctioned during the previous year are cancelled.

In practice, the new mechanism means that allowances can be cancelled if the allowance surplus is large. Hence the long-run emissions cap is no longer determined by the politically-prescribed quantity of issued allowances over the lifetime of the EU ETS.

Model simulations indicate that the new agreement implies a higher allowance price and lower accumulated CO_2 emissions in both the short and the long run. Specifically, the simulations indicate that the accumulated CO_2 emissions in the EU ETS are reduced by 3-4 per cent from 2017 to 2050 and by 4-16 per cent from 2017 to 2100.

Denmark has no obligations to reduce greenhouse gas emissions from sectors covered by the EU ETS. Nonetheless, for many years Danish governments have conducted climate policies that affect CO_2 emissions from these sectors. These policies include subsidies to renewable energy. The Chairmen of the Danish Council of Environmental Economics have previously expressed scepticism about these national climate policies, as these policies were unable to reduce CO_2 emissions within the EU ETS. This assessment was based on the observation that, in the long run, the total CO_2 emissions in the EU ETS was determined by the politically-prescribed quantity of issued allowances over the lifetime of the EU ETS. However, after the new agreement, national climate policies might affect the long-run aggregate emissions in the EU ETS, since national policies can affect the allowance surplus and, thereby, the allowance amounts placed and cancelled in the MSR.

To investigate the effect of the November 2017 agreement, the long-run impact on CO_2 emissions of national climate policies is analysed both before and after the new agreement. Specifically, two types of national policies are analysed: 1) policies that reduce the demand for allowances, and 2) national allowance cancellations. Examples of the former include subsidies to renewable energy and a national tax on CO_2 emissions.

Model simulations indicate that, before the November 2017 agreement, policies that reduced the demand for allowances did not affect the long-run aggregate emissions in the EU ETS. In contrast, national allowance cancellations could reduce the aggregate long-run emissions before the new agreement. If, for instance, 8 million allowances were cancelled, the long-run aggregate emissions in the EU ETS would be reduced by 8 million tonnes of CO_2.

After the new agreement, policies that reduce the demand for allowances can affect the long-run aggregate emissions in the EU ETS. The intuition is as follows. If the demand for allowances is reduced, the allowance surplus becomes larger. A larger allowance surplus leads to a larger intake of emission allowances in the MSR and, thereby, the allowance amounts cancelled in the MSR. Model simulations indicate that policies that reduce the allowance demand by 8 million allowances – before allowing for changes in the allowance price – reduce the long-run aggregate emissions in the EU ETS by 1.4-6.8 million tonnes of CO_2.

In contrast, national allowance cancellations have become less effective in terms of long-run emission reductions under the new agreement, as the cancellation of 8 million allowances now leads to a reduction of less than 8 million tonnes of CO_2 in the long run. Specifically, model simulations indicate that the cancellation of 8 million allowances reduces the long-run aggregate emissions in the EU ETS by 1.5-6.6 million tonnes of CO_2.

The model simulations indicate a significant amount of uncertainty associated with the effects of the two types of national policies investigated. The effects depend on multiple factors including technological development and when the policies are implemented. Thus it is difficult to assess which type of national policy most effectively reduces the long-run aggregate emissions in the EU ETS.

Some EU countries – including Denmark – have the option to cancel emission allowances to reduce their emission reduction obligations in the non-ETS sector for the period 2021-30. A provisional agreement

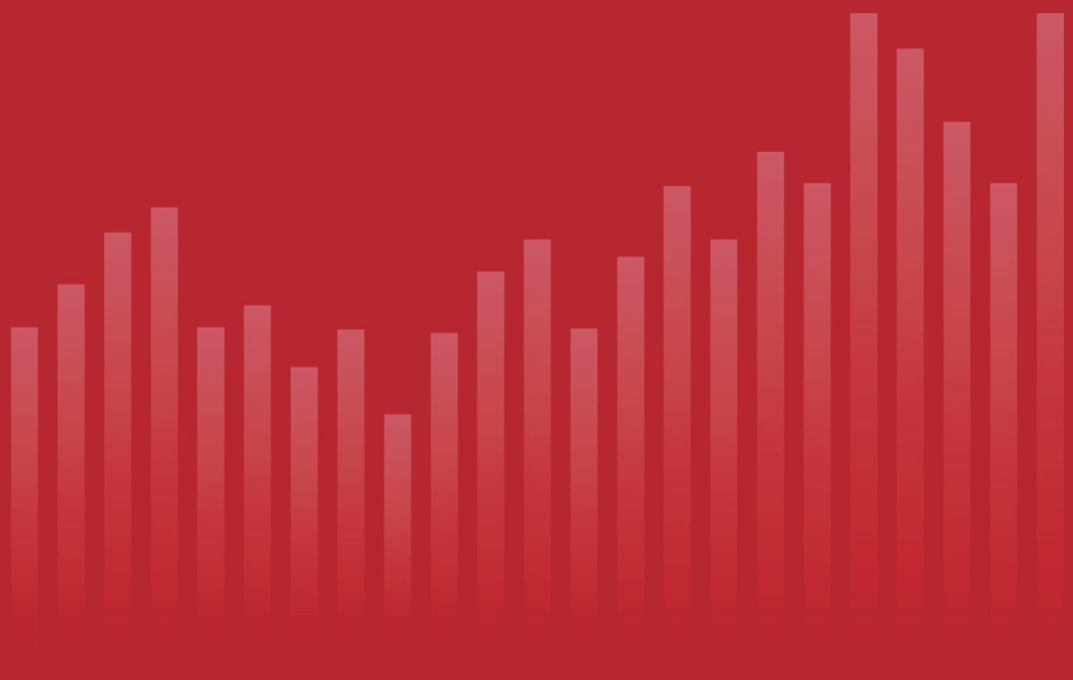
between the European Council and the European Parliament implies that allowances cancelled to reduce non-ETS emission reduction obligations only count on the supply side when the allowance surplus is computed. This rule amplifies the effect of this type of allowance cancellation. Model simulations indicate that if 8 million allowances are cancelled to reduce non-ETS emission reduction obligations, the long-run aggregate emissions- in the EU ETS is reduced by more than 8 million tonnes of CO_2. The intuition is as follows. The cancellations reduce the allowance amounts available in the period 2021-30. As a reaction to this increased allowance scarcity, firms in the EU ETS save more allowances in the short run. This increases the allowance surplus in the short run and, thereby, the allowance intake and cancellations in the MSR. Meanwhile, the agreement ensures that the surplus is not reduced directly by the allowance cancellations.

As mentioned above, Denmark does not have an obligation to reduce emissions in sectors covered by the EU ETS, as these emissions are regulated by the EU. If Denmark wants to reduce its emissions from sectors covered by the EU ETS, this might be done through policies that reduce the demand for allowances. This could be done by subsidizing renewable energy or by imposing a national tax on CO_2 emissions in sectors covered by the EU ETS. This report does not analyse how to cost-effectively reduce the demand for allowances. Yet it seems plausible that a cost effective policy would include a combination of subsidies to renewable energy and a tax on CO_2 emissions. Due to carbon leakage, it would be an advantage if a tax on CO_2 emissions in sectors covered by the EU ETS were implemented in multiple countries.

A notable consequence of the November 2017 agreement is that it reduces the effect of moving CO_2 emissions from the non-ETS sector to sectors covered by the EU ETS. Before the new agreement, long-run aggregate emissions in the EU would be reduced by 8 million tonnes of CO_2 if 8 million tonnes of CO_2 emissions were moved from the non-ETS sector to sectors covered by the EU ETS. After the new agreement, the same movement of emissions has a smaller effect. Intuitively, moving emissions to sectors covered by the EU ETS increases the demand for emission allowances. This reduces the allowance surplus. As the allowance surplus is reduced, fewer allowances are placed and cancelled in the MSR. Electric cars and heat pumps are examples of technologies that move emissions from the non-ETS sector to sectors covered by the EU ETS. Hence, after the new agreement, subsidies to these technologies become less effective in terms of reducing aggregate emissions at the EU level.

All in all, the new agreement leads to a reduction in the allowance surplus and a higher allowance price. Seen in isolation, this is a positive development. However, the agreement also leads to a more complex cap-and-trade system. This is a weakness of the agreement, as the increased complexity makes it harder for Denmark and other EU countries to conduct cost-effective climate policies.

If Danish policy makers want to reduce CO_2 emissions beyond the national obligation, national allowance cancellations used to reduce non-ETS emission reduction obligations seem cost effective. If this policy option is not already being fully utilised to meet Denmark's emission reduction obligations in the non-ETS sector, full use of this policy option seems like a good place to start in an attempt to cost-effectively reduce the global CO_2 emissions.



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