REV0186: Additional Information

This note provides additional information with regard to the request for revision REV0186 that is work in progress by the Meth Panel. The information may also be useful in the context of the investigation started as a result of the request REV0186.

Assessment of the impacts of potential over-production of HCFC-22 in CDM plants

The data submitted in the request for revision REV0186 showed that for some CDM plants the amount of HCFC-22 produced appears to be strongly driven by the possibility to generate CERs. Despite the caps on the amount of HCFC-22 eligible for crediting it is possible that some CDM plants have produced more HCFC-22 than they would have done in the absence of the project activity, given the strong economic incentives from the CDM and the relatively generous cap on HCFC-22 production (using the maximum production in three historical years and accounting for CFC production). In the following, the possible implications of such increased production in CDM plants are discussed.

Currently, the global HCFC-22 production is approximately distributed as follows: about 1/3 is produced in industrialized countries, about 1/3 in CDM plants and about 1/3 in non-CDM plants in developing countries. Hence, there is a considerable amount of HCFC-22 produced in non-CDM plants in developing countries and the market demand clearly exceeds the production by CDM plants. Given that HCFC-22 has a market price, it would be economically rational for the operators to sell any excess HCFC-22 produced, even if the CER revenues exceed the HCFC-22 production costs. For this reason, it can be deemed as rather unlikely that an increased HCFC-22 production in CDM plants would result in a direct release of HCFC-22 into the atmosphere. An increase of HCFC-22 production due to the CDM would thus rather displace the production in other HCFC-22 production plants. These other plants can include a) plants in industrialized countries and b) non-CDM plants in developing countries.

A displacement of HCFC-22 production in industrialized countries would imply that the emission reductions from this increased production do not represent any real emission reductions, given that the total emissions by Kyoto Parties are capped and given that most plants in industrialized countries abate HFC-23 to a large extent. The production in industrialized countries declined continuously from 361 kt in 2000 to 292 kt in 2008, suggesting that the plant utilization is decreasing in industrialized countries and that there is considerable over-capacity. In contrast, production in developing countries increased in the same time from 117 kt to 542 kt and CDM plants run at a very high load – to the extent that they can claim CERs. Due to the revenues from CERs, the marginal HCFC-22 production costs are likely to be negative but are in any case much lower than in industrialized countries.[1] Since HCFC-22 continues to be used in industrialized countries for feedstock application and essential use exemptions and since transportation costs are small compared to CER revenues, it is possible that increased production in CDM plants displaces production in industrialized countries.

[1] The economic implications of the CDM on HCFC-22 production costs have been extensively researched (see, for example, TEAP 2007).

A displacement of HCFC-22 production in non-CDM plants is more difficult to assess. The net effect depends on the HFC-23/HCFC-22 ratio in the affected CDM plant and in the plants where the HCFC-22 production is displaced. As discussed in detail below, it is likely that non-CDM plants tend to have a lower HFC-23/HCFC-22 ratio compared to CDM plants. If this is the case, this would imply that emission reductions are overestimated with the current methodology because in the absence of the CDM less HFC-23 would have been generated in the displaced plants than is generated in the project plant.

HFC-23/HCFC-22 ratio in the absence of the CDM

In assessing the implications of the observed behaviour of HCFC-22 plant operators, it is important to assess what would be a likely HFC-23/HCFC-22 waste ratio in the absence of the CDM. In the following, additional available information on this matter is discussed.

1) Newer plants tend to lower HFC-23/HCFC-22 ratios

The TEAP (2007) assumed an HFC-23/HCFC-22 ratio of 1.5% for industrialized countries and a value of 3% for developing countries. The TEAP justifies this difference as follows: "The origins of these differences tend to lie in the *age* and *design* of the plants, with emissions being more difficult to control in 'swing' plants'" (emphasize added). Similarly, the Fund Secretariat of the MLF highlighted that "new [HCFC-22] firms employing state-of-the art technology generally have better yields, fewer leaks and lower emissions than older enterprises" (UNEP/OzL.Pro/ExCom/57/61, page 9). Apparently, newer plants tend to have lower HFC-23/HCFC-22 ratios. As non-CDM plants are newer, this suggests that they should also have lower HFC-23/HCFC-22 ratios.

2) Swing plants tend to have higher HFC-23/HCFC-22 ratios

The TEAP (2007) reports that swing plants tend to have higher HFC-23/HCFC-22 ratios. "In swing plants, for instance, due to the necessary compromise in design, process optimisation is a more difficult task, and they are therefore expected to operate at the higher end of the emission range, producing about 3-4% emissions" (TEAP 2007, page 51). Due to the possibility to produce different products, the plant design makes it more difficult to reduce the by-product ratio.

Although a small sample, the available data on HFC-23/HCFC-22 ratios from PDDs and the evaluated monitoring reports confirms this. Five registered projects declare in their PDD that they are swing plants. Four registered projects explicitly state in their PDD that they are not swing plants (or they state that they did not produce any CFCs). In the case of 10 projects, all located in China, no information is available in the PDD whether or not they are swing plants. A comparison of the five swing plants with the four non-swing plants shows that the HFC-23/HCFC-22 ratio is in both the historical 2000 to 2004 period and during monitoring on average about 0.5% higher for swing plants than for non-swing plants.

While at least five registered CDM projects are swing plants, it is unlikely that new facilities, which started commercial operation in 2002 or later, are swing plants because in most countries, including China, CFC production was phased out already in 2007. This suggests that on average the HFC-23/HCFC-22 ratio of CDM plants (which include swing

plants) is likely to be higher than for non-CDM plants (which most likely do not include any swing plants).

3) Derivation of HFC-23/HCFC-22 ratios from atmospheric and production data

Montzka et al. (2009) derived an estimate of 3.7% for the HFC-23/HCFC-22 of plants not covered under the CDM. This value was derived for the period 2006 to 2008 and is based on a) an estimate of global HFC-23 emissions which was inferred from atmospheric data, b) HFC-23 emissions data reported by industrialized countries, c) HCFC-22 production reported by governments to the UNEP Ozone Secretariat and d) HCFC-22 production data of CDM plants reported in monitoring reports. The basic algorithm is the following:

$$w_{non-CDM} = \frac{(\text{Global HFC23 emissions} - \text{Annex I HFC23 emissions})}{(\text{NonAnnex I HCFC22 production} - \text{HCFC22 production of CDM plants})}$$

The result of the analysis, an inferred value of 3.7% is significantly higher than the historical average HFC-23/HCFC-22 ratio of CDM plants (around 3%). It thus contradicts the technical aspects discussed above, which suggest that newer plants are likely to have lower HFC-23/HCFC-22 ratios. However, there are several issues which may have considerable impact on the inferred value for w:

- **Measurement inaccuracies in the derivation of global HFC-23 emission estimates.** Inaccuracies in the measurement of atmospheric HFC-23 concentrations and derivation of global HFC-23 emissions can be a very significant source of uncertainty. Miller et al. (2010) conducted a similar analysis as Montzka et al. (2010) but arrived at significantly lower global HFC-23 emission rates for the years 2007 and 2008 (10.3 and 10.1 Gg instead of 13.5 Gg). If the global emission rates from Miller et al (2010) would be used in the calculations by Montzka et al (2010), the inferred value of w for non-CDM plants would amount to 2.86%. In addition, we note that for the period 2000 to 2005, the w value inferred by Montzka et al (2010) for non-CDM plants is 2.9% (using the data from Montzka in Supplement Table 2) – a value that is lower than the w reported from CDM plants for the same period. It is unclear why this should have changed and why the inferred value in non-CDM plants should have increased drastically between the 2000 to 2005 period to the 2006 to 2008 period. It thus seems plausible that the data by Miller is more reliable than the data used by Montzka. However, the large difference between the two estimates shows that the overall uncertainty associated with an inferred w value is relatively high and difficult to use for a conclusion on the actual waste ratios in non-CDM plants.
- **Assumption that CDM plants do not emit HFC-23.** Montzka et al (2010) implicitly assumed that all HFC-23 from CDM plants is abated. AM0001 does not require plants to abate all HFC-23. Moreover, plant operators do not have economic incentives to abate any HFC-23 which is not eligible for crediting. Finally, the HFC-23 destruction facilities may not work continuously and HFC-23 may be vented when they are not operational. While some PDDs explicitly state that nevertheless all HFC-23 is abated (apart from very minor emissions due to incomplete oxidation), there are other plants for which the monitoring data suggests that some HFC-23 is vented to the atmosphere and only the amount eligible for crediting is actually destroyed. This

means that the HFC-23 emissions of non-CDM plants are actually lower and that the inferred HFC-23/HCFC-22 may be too high. Not all monitoring reports provide information on the amount of HFC-23 generated. It is therefore not possible to quantify this effect.

- **Inaccuracies in the reporting of HCFC-22 production.** There could be inaccuracies in the amount of HCFC-22 production reported to the UNEP/Ozone secretariat and/or potential discrepancies with amounts reported under the CDM. The available data puts into question whether the amount of HCFC-22 production reported to the UNEP secretariat is consistent with the amounts reported in CDM plants. There is a possibility that the actual HCFC-22 production was higher than the amount reported to the UNEP/Ozone Secretariat or that the amount of production reported under the CDM is not correct.[2] If the actual HCFC-22 production is larger than reported to the UNEP/Ozone Secretariat, this would result in an overestimation of the derived HFC-23/HCFC-22 ratio for non-CDM plants.
- **Inaccuracies in HFC-23 emissions reported by industrialized countries.** The emissions reporting by industrialized countries may be partially based on default values and not on actual measurements of HFC-23 emissions, as required under the CDM. For example, the Revised 1996 IPCC Guidelines, applicable to GHG inventories under the Kyoto Protocol until 2012, allow under Tier 1 to use a default value for the HFC-23/HCFC-22 ratio of 4% for unabated plants. This factor was based on a study from 1994 and is likely to be too high according to more recent information.
- **Storage of HFC-23.** Over the past years considerable amounts of HFC-23 were stored in China in tanks at the plant sites, in order to destroy the HFC-23 at a later stage under the CDM, once the destruction facilities are installed and operational. The stored amounts are not known and we do not have information whether these amounts were eventually destroyed or partially released to the atmosphere. The effects of the storage are not clear and could go into different directions, depending when and for how long the HFC-23 was stored, how much was stored and whether it was finally destroyed or released to the atmosphere. For example, a release around 2006-2008, when it became clear that stored amounts are not eligible for destruction under the CDM, could have contributed to the increased inferred total emissions and result in an overestimation of the inferred HFC-23/HCFC-22 ratio. However, this is rather speculative and the impact of storage could also be different or relatively small.

[2] A good comparison year is 2002. In 2002, new capacity not eligible under the CDM may still be rather limited. According to data reported by governments to the UNEP/Ozone secretariat, the total reported HCFC-22 production in developing countries, including use for both emissive and feedstock purposes, amounted to **175 kt** in 2002. Among the 19 registered CDM projects, 13 projects report HCFC-22 production for 2002 in their PDD or in their PDD for requesting renewal of the crediting period (6 projects do not provide historical HCFC-22 production data in their PDD). The total HCFC-22 production of these 13 plants amounts to **147 kt** in 2002. If one assumes that both numbers are correct, then the difference (**27 kt**) would be produced by the remaining plants that were operating in 2002. These include at least 8 plants, including: 6 registered CDM projects which do not report historical HCFC-22 production data, of which 5 are swing plants, and two plants which are not (yet) registered under the CDM, one in Venzuela and one production line in Mexico. In addition, some HCFC-22 may have been produced in new plants which became operational in 2002. It seems questionable that these 8 (or even more) plants have not produced more than 27 kt in 2002. A more complete picture may become available, once detailed production data is available for all CDM plants, as requested recently in requests for review for the issuance of a number of projects.

In summary, although the method applied by Montzka et al (2009) to derive the HFC-23/HCFC-22 ratio of non-CDM plants is correct, we believe that the uncertainty of the derived value of 3.7% is considerable in the light of the issues discussed above. Moreover, a comparison with the global HFC-23 emissions derived by Miller et al (2010) and the issues discussed above tend to suggest that the derived HFC-23/HCFC-22 ratio may be rather overestimated than underestimated. Due to the large uncertainties and the large discrepancy between the two estimates, it seems that w ratios inferred from atmospheric measurements have a considerable uncertainty and are not suitable to determine the HFC-23/HCFC-22 ratio in non-CDM plants in a sufficiently reliable manner. Finally, there are several technical reasons to assume that non-CDM plants tend to have lower HFC-23/HCFC-22 ratios than CDM plants had historically prior to the installation of the HFC-23 incinerators.

Phase-out of HCFC-22 under the Montreal Protocol

Under the Montreal Protocol, preparatory work started to implement the accelerated phase-out of HCFCs, as decided in 2007. As a basis for funding the phase-out, technical audits of HCFC production are planned to be conducted. These audits examine the relevant national and sectoral policies; collect data on ODS-producing plants with respect to their technological sophistication, status quo, designed and actual used capacity, production history, cost of production, and other relevant data. In the case of HCFC-22, the audit is planned to also assess the impact of the CDM (see Annex IX of UNEP/OzL.Pro/ExCom/60/54 for the terms of reference). However, the results of the audit will most likely only become available over the next years.

In the context of the phase out and the crediting under the CDM, two important questions emerge:

1) To which extent could the HCFC-22 production be absorbed by feedstock demand and to which extent will it be necessary to close down existing plants or switch production to ODS replacements?
2) If plants closure is necessary: which plants would (in the absence of the CDM) be closed down first and does the CDM provide disincentives for plant closure?

Regarding the first question, the UNEP reports that it is unlikely that the existing HCFC-22 production for emissive uses can be converted to production for feedstock demand (UNEP/OzL.Pro/ExCom/59/50 Annex II). The feedstock demand is generally expected to grow further (see e.g. TEAP 2007). However, there is a considerable feedstock production capacity which is apparently larger than the current demand.[3] Secondly, the use of HCFC-22 as feedstock is restricted by the quality of the HCFC-22. Lower qualities of HCFC-22 can only be used for emissive uses (UNEP/OzL.Pro/ExCom/57/61, page 9). It is not clear to what extent the existing HCFC-22 are technically capable of producing HCFC-22 with the required quality for feedstock applications. At least, some plants would require retrofits to enable them to produce HCFC-22 with sufficient quality for feedstock applications.

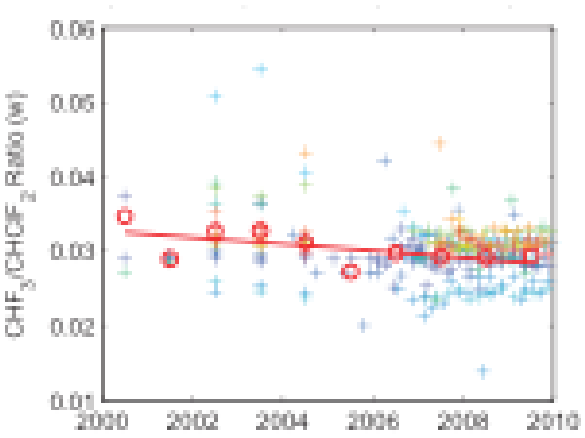
[3] The production capacity is referenced in UNEP/OzL.Pro/ExCom/59/50 Annex II, the production for feedstock purposes, as reported to the UNEP Ozone Secretariat by Parties, is illustrated in REV0186.

This suggests that at least in some cases plant closure will be necessary. In the absence of the CDM it would be likely the elder, less efficient, and smaller plants may be closed down first. However, with the incentives from the CDM there is a practical risk that HCFC-22 plant operators and governments may resist closure of their plants due to the incentives from the CDM. A similar experience occurred during the CFC phase-out under the Montreal Protocol: once prices for CFCs rose as a result of a decrease in supply due to the phase-out, some CFC producers resisted closure due to the benefits from the profits generated from scarcity (UNEP/OzL.Pro/ExCom/57/61, page 10). Given that the incentives from the CDM for continued HCFC-22 production are much larger than the profits from continued CFC production, there is a much higher risk for such behaviour in the case of HCFC-22 phase-out if full crediting under the CDM is continued.

This could lead to a situation where HCFC-22 production is continued above levels that would occur without the CDM and/or that HCFC-22 is produced in plants with a potentially higher HFC-23/HCFC-22 ratio than in the absence of the CDM (see discussion above). These perverse incentives from the CDM to continue production of HCFC-22 could become an issue already over the next few years in the negotiations on implementation of the HCFC phase out. This could potentially lead to a delayed phase out of HCFC-22 with negative implications for reducing both ozone depleting substances and greenhouse gases. In this context it is also important to emphasize that the CFC phase-out under the Montreal Protocol occurred faster in most countries than legally required under the Protocol. If the incentives from the CDM did not exist, it seems plausible that this could also be achieved for the phase out of HCFCs. However, the strong economic incentives from the CDM for both plant operators and governments may result in a slower phase-out.

Autonomous technological improvements

Miller et al. (2010, page 13215) conducted a similar evaluation of all monitoring reports and PDDs to assess the development of the HFC-23/HCFC-22 ratio over time. The results are shown in the figure below and largely confirm the finding in the revision request REV0186 that HFC-23/HCFC-22 tended to decrease over time. The red circles correspond to the annual mean ratios, weighted by the production amounts. Table 4 in Miller et al (2010, page 13211) also shows that continuously declining HFC-23/HCFC-22 ratio for CDM plants from 1990 to 2009.



Conclusions

As highlighted by the Meth Panel in its note to the Board, there are different issues that may need to be tackled in a revision of the methodology. Many issues could be addressed by choosing a HFC-23/HCFC-22 ratio of about 1.0% (given that one plant in China achieved without CDM incentives a ratio of 1.1%, the best practice values indicated in the TEAP of 1.4% may not reflect more recent developments).

However, such a value would still provide considerable economic incentives from the CDM – based on the figures provided by the TEAP, CER revenues could still be larger than HCFC-22 production costs – which could still provide incentives that more HCFC-22 is produced as a result of the CDM than would otherwise be produced. As long as this incentive exists, there are two issues which can not be addressed: 1) the potential displacement of HCFC-22 production in plants in industrialized countries and 2) the negative implications for the phase-out of HCFCs under the Montreal Protocol. In both cases, the perverse incentives can lead to a situation where emission reductions would not be real, as explained in detail above.

We therefore believe that either a lower HFC-23/HCFC-22 ratio has to be chosen (as suggested in the request REV0186). A potential alternative could be a lower cap on the HCFC-22 production eligible for crediting. If chosen sufficiently low, it could potentially address the issue of displacement of production in industrialized countries. However, it would not address the perverse incentives to resist plant closure in the context of the phase out under the Montreal Protocol. We therefore doubt that this alternative option fully addresses the issues raised in the context of the phase out of HCFCs under the Montreal Protocol.

The table below summarizes the different issues that emerge in the context of the revision request REV0186.

Issues and implications	**Discussion of ways to address the issue**
HCFC-22 production in CDM plants is due to the CDM higher than in the absence of the CDM	
⇨ Displacement of production in non-CDM plants	Issue could be addressed by a lower baseline value for w (e.g. 1.0%)
⇨ Displacement of production in plants in industrialized countries	Issue would not be addressed by a value of w of e.g. 1.0%. With a significantly lower value (e.g. 0.2%) the perverse incentives for such production shifts would be largely reduced and any continuing production shift would likely be compensated as this w value would imply that less CERs are issued than emission reductions occur at the plant site.
Operation of plants at a higher HFC-23/HCFC-22 ratio than would occur without the CDM	Issue could be effectively addressed by using a lower baseline value for w (e.g. 1.0%)
Resistance to plant closure in phasing out HCFCs under the Montreal Protocol due to incentives from the CDM	This risk could only be mitigated by largely removing the strong economic incentives from the CDM (e.g. with a baseline value for w of 0.2%)

Growth in HCFC-22 demand for feedstock applications is unlikely to absorb production for emissive uses, potentially resulting in excess production of HCFC-22	Lowering of the caps on HCFC-22 production or removing economic incentives to continue HCFC-22 production (e.g. with a baseline value for w of 0.2%)
Prolongation of the technical lifetime of plants due to the CDM	Environmental risk could be effectively mitigated by either using a lower value for w (e.g. 1.0%) or limiting the crediting to the technical lifetime of the plants
HFC-23/HCFC-22 may lower over time due to autonomous technological improvements	This could be addressed by either using a lower value for w (e.g. 1.0%) or by introducing a factor to account for autonomous technological improvement over time (using each year a lower value for w)

References

TEAP (2007): Response to decision XVIII/12. Report of the task force on HCFC issues (with particular focus on the impact of the Clean Development Mechanism) and emissions reduction benefits arising from earlier HCFC phase-out and other practical measures. August 2007

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