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Technical Correction to the Forest Management Reference Level under the Kyoto Protocol for the Netherlands

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1 Introduction

1.1 General description of the FMRL of the Netherlands

The Netherlands was one of the EU Member States for which the Joint Research Centre (JRC) of the European Commission, in collaboration with the European Forest Institute (EFI) and IIASA developed the projections of the FMRL using a suite of models (see Table 1.1) and input data.

The elaborated reference level was built on projections under a business as usual (BAU) scenario, which was based on macro-economic drivers such as GDP and population growth which were exogenous to the models used, and on policies and measures enacted by Member States up to April 2009. These projections reflected the economic downturn at the time of elaboration of the reference levels in the years before 2010, and assumed that these would be followed by sustained economic growth after 2010. This data provided input into the GLOBIOM model to assess future demand for wood (see main assumptions for the baseline scenario in Capros et al. (2010; on pp.13-16) for more information). Bioenergy demand was projected by the PRIMES large scale energy model for Europe. These economic land use models projected domestic production and consumption, net exports and prices of wood products and changes in land use for the baseline scenario (BAU) for EU member states and other world regions. See section 6 of the original submission[1] of the FMRL by the Netherlands for more information on policies included.

Subsequent data on potential yields and GHG emissions and CO_2 removals for diverse forest management alternatives were derived from the more detailed forestry models (G4M and EFISCEN) using the sector specific information from the economic models. The area of Forest Management used by the models was taken from national forest inventories (EFISCEN) or from literature reflecting the situation at the time of projecting the FMRL (G4M). The main forest characteristic and forest management parameters like age structure, increment and historical harvest were taken from NFI data and/or other country statistics. The two models differed, however, in the way they allocate harvest demand to thinnings and final fellings (including rotation lengths) with implications on emissions and removals from the forest. In general, both models follow the rules of sustainable forest management, securing sustainable yields. Further the models follow different growth concepts: in EFISCEN forest growth is based on NFI data, whereas G4M estimates growth from productivity (NPP) maps representing alternative approaches of forest growth estimation and projection.

For a more detailed description of the approaches and methods used to derive the FMRL for the Netherlands see the original submission of the FMRL for the Netherlands[1]

***Table 1.1**. Features of the main models that were used for elaborating the FRML of the Netherlands (source: the original submission of the FMRL by the Netherlands[1]).*

Model	Description
G4M	The Global Forest Model (G4M) provides spatially explicit estimates of annual above- and belowground wood increment, development of above- and belowground forest biomass and costs of forestry options such as forest management, afforestation and deforestation by comparing the income of alternative land uses.
EFISCEN	The European Forest Information Scenario Model (EFISCEN) is a large-scale model that assesses the supply of wood and biomass from forests and projects forest resource development on regional to European scale, based on forest inventory data. EFISCEN provides projections on basic forest inventory data (stemwood volume, increment, age-structure), as well as carbon in forest biomass and soil.
GLOBIOM	GLOBIOM is a global static partial equilibrium model integrating the agricultural, livestock, bioenergy and forestry sectors with the aim to give policy advice on global

[1] https://unfccc.int/files/meetings/ad_hoc_working_groups/kp/application/pdf/awgkp_netherlands_frml_2011.pdf

Model	Description
	issues concerning land use competition between the major land-based production sectors.
PRIMES	PRIMES is an economic supply model that computes the optimal use of resources and investment in secondary and final transformation, so as to meet a given demand of final biomass energy products, driven by the rest of sectors as in PRIMES model. The primary supply of biomass and waste has been linked with resource origin, availability and concurrent use (land, forestry, municipal or industrial waste etc). The total primary production levels for each primary commodity are restricted by the technical potential of the appropriate primary resource.

The 'Submission of information on forest management reference levels by the Netherlands'[2] of 20 April 2011 contains the information on the FMRLs as original submitted. After a correction in the calculation matrix of the HWP model, changes in the submission of information on FMRLs by the Netherlands were communicated on 20 May 2011[3]. These corrections contain updated values of the proposed reference levels.

During the subsequent technical assessment of the submission mentioned above, the ERT noticed discrepancies in the area data used by the models. As result, the Netherlands reran the models with updated area data. This resulted in a revised FMRL of -1.464 Mt CO_2 eq. per year (average 2013–2020) assuming instantaneous oxidation of HWP and a revised FMRL of -1.425 Mt CO2 eq. per year applying a first-order decay function to HWP.

These numbers are included in the 'Report of the technical assessment of the forest management reference level submission of the Netherlands submitted in 2011', FCCC/TAR/2011/NLD[4], 19 September 2011.

1.2 Why the technical correction to the FMRL?

Since the submission of the FMRL in 2011, the LULUCF inventory has seen many smaller and larger methodological improvements. As a result the historical emissions and removals have been recalculated and, moreover, the data and methodologies used for the FMRL no longer are consistent with the methodologies used in the current Dutch LULUCF GHG inventory.

Important changes since 2011 (see methodologies in van den Wyngaert et al. (2011a; 2011b)) and the current inventory (see Arets et al. (2021)) include:

- New NFI data (NFI-6) collected between September 2012 and September 2013, covering the period 2003-2013
- The new NFI data allowed the GHG-inventory for forest land to be based on a stock change methodology, whereas in earlier GHG inventories a gain-loss approach was used
- New land-use data (maps on 1-1-2013, 1-1-2017) with actual changes in forest land (and area of Forest Management) resulting in inconsistencies between the reported emissions and removals in FM and those included in the FMRL.
- Inclusion of land-use information in 1970 resulting in a change in the distribution of the area of forest land remaining forest land and land converted to forest land in the period 1990-2010. While this will not affect areas of FM and AR, it will have an effect on the carbon stock changes in FM as part of it now is considered < 30 years old and follows the young forest growth rates.
- Since 2011 also emissions from drainage of organic soils and biomass burning has been included in the methodologies, which were not yet considered in the FMRL.

[2] https://unfccc.int/files/meetings/ad_hoc_working_groups/kp/application/pdf/awgkp_netherlands_frml_2011.pdf
[3] https://unfccc.int/files/meetings/ad_hoc_working_groups/kp/application/pdf/awgkp_netherlands_corr.pdf
[4] http://unfccc.int/resource/docs/2011/tar/nld01.pdf

- Historic harvest data have been revised (i.e. 1990 values) and the way harvest were classified as industrial roundwood (contributing to HWP) and fuel wood (instantaneous oxidation) were adjusted, resulting in a shift in the shares of both wood categories (see Annex 4 in the methodological background document for LULUCF; Arets et al. 2021)

Moreover a technical correction is necessary to take into account the rules on accounting of HWP as agreed in decision 2/CMP.7 were not yet available at the time the FMRLs were submitted: natural disturbances were not yet included at the time of submission of the FMRLs.

As a result, before accounting at the end of the commitment period a technical correction of the FMRL of the Netherlands will be necessary. This note provides more background to the calculation of the technical correction to the Forest Management Reference Level (FMRL) of the Netherlands, related to the NIR 2021. In 2022 a final technical correction will be necessary to be able to account for data and methodology changes applied to the reporting in the NIR 2022.

2 Methods

2.1 General approach

To cover the various changes leading to inconsistencies between FM and FMRL, technical corrections need to be applied to the adopted FMRL. This technical correction is based on the difference between the adopted FMRL and a newly calculated FMRL ($FMRL_{corr}$).

To assess the $FMRL_{corr}$ the original inputs used in the assessment of the adopted FRML are included within the current methodologies (see Section 4.2 in Arets et al. (2021)) to assess emissions and removals for FM. As a result the projected business-as-usual development in forest structure, harvests and HWP profile of the adopted FMRL are maintained, but subsequent calculations of emissions and removals are consistent with the latest methodologies used for reporting FM. This also ensures consistency in the development of the area of Forest Management over time and prevents differences as a result of differences in changes in areas of FM between the reported emissions and removals and those in the $FMRL_{corr}$.

The adopted FMRL was based on projections of forest structure using a combination of runs of the EFISCEN and G4M models (see introduction section 1.1). Both models were driven by the future demand for wood as projected by the GLOBIOM model. The results of the models were then used to calculate changes in carbon stocks in forest management.

The current reporting of FM is based on the calculation carried out for forest land remaining forest land (see Section 4.2 in Arets et al. (2021)). It uses the information on growing stock from NFIs and in years that no new NFI is available yet (as is the case in NIR2021) projected growing stock as produced by the EFISCEN model is used as an estimate for the future inventory values[5] (see Section 4.2 in Arets et al. (2021) and Figure 2.1 below, with the 7th NFI (NFI-7) already included in the graphical overview). For the technical corrections the EFISCEN model is used in a similar way to assess the information on growing stock and carbon stock changes in FM for the $FMRL_{corr}$ (see Figure 2.2).

In contrast to the development of the FMRL, for assessing the $FMRL_{corr}$ only the EFISCEN model is used. Reasons for this are that the EFISCEN model (Verkerk et al. 2016) is co-developed by the team that is also responsible for the Dutch LULUCF GHG inventory, which means that there is direct access to the modelling environment, but also that the model has been demonstrated to well reflect actual forest developments in the Netherlands. Another reason for choosing the EFISCEN model, is that it is based on NFI data and that the type of output is very similar to the type of NFI data that is used in the regular reporting of forest land and KP forest management as described in Arets et al. (2021).

Another difference to the model use for elaborating the FMRL is the way the outputs are used. For FMRL direct output from EFISCEN and G4M were used to assess emissions and removals. In the approach for $FMRL_{corr}$ the output on growing stock from the EFISCEN model are used in the LULUCF bookkeeping model in a similar way as the information from the National Forest Inventories in the annual reporting of FM (see Section 4.2 in Arets et al. (2021) and Figures 2.1 and 2.2 below). As a result the methodologies for calculations the development of FM area, and emissions and removals of FM are the same for reporting FM and $FMRL_{corr}$. The only difference is in the development of forest structure, which for the FMRL is based on the EFISCEN projections including the projected harvests as assessed by GLOBIOM for the adopted FMRL and the inputs into the HWP for the period 2010-2020 which were based on the same GLOBIOM projections. The approach is similar to the approach applied for assessing the Dutch Forest Reference Level under the EU LULUCF regulation (EU 2018/841), see Arets and Schelhaas (2019).

[5] Note that in the NIR2022 for reporting on forest land under the UNFCCC and Forest Management under the Kyoto Protocol these projected data will be replaced by actually measured results from the NFI-7, which started in 2017 and will be finalised mid-2021.

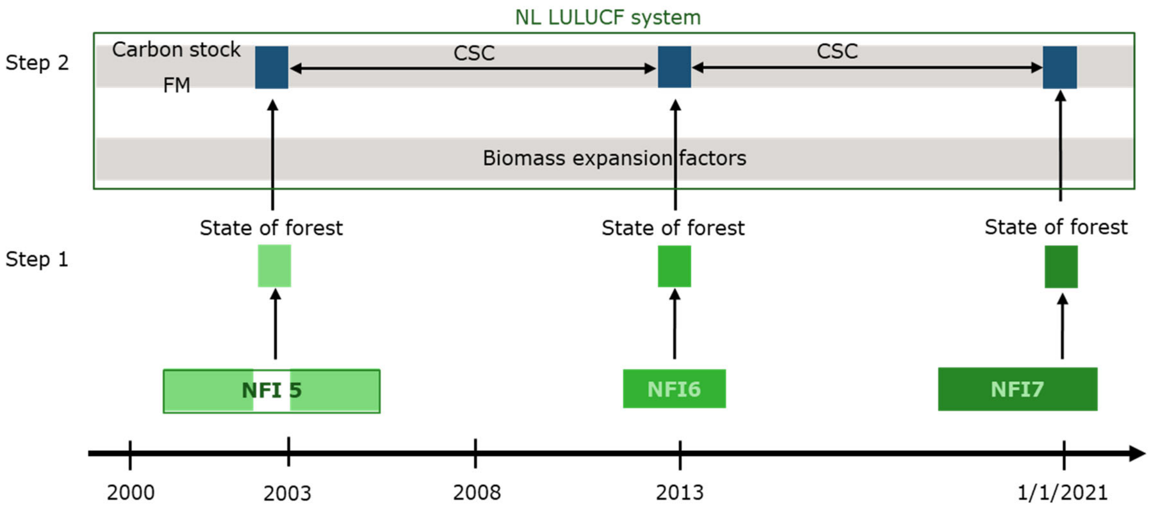

Figure 2.1. *Graphical overview of the approach applied for estimating the carbon stock changes in the regular reporting of Forest Management. Data from the NFI5, NFI6 and NFI7 are used to assess average growing stock, share of conifers and broadleaved species and amounts of standing and lying dead wood. Using biomass expansion factors these are then converted to average aboveground biomass, belowground biomass and dead wood biomass that is used in the NL LULUCF bookkeeping model to assess carbon stocks and carbon stock changes (CSC). Also see section 4.2.1 in Arets et al. (2021).*

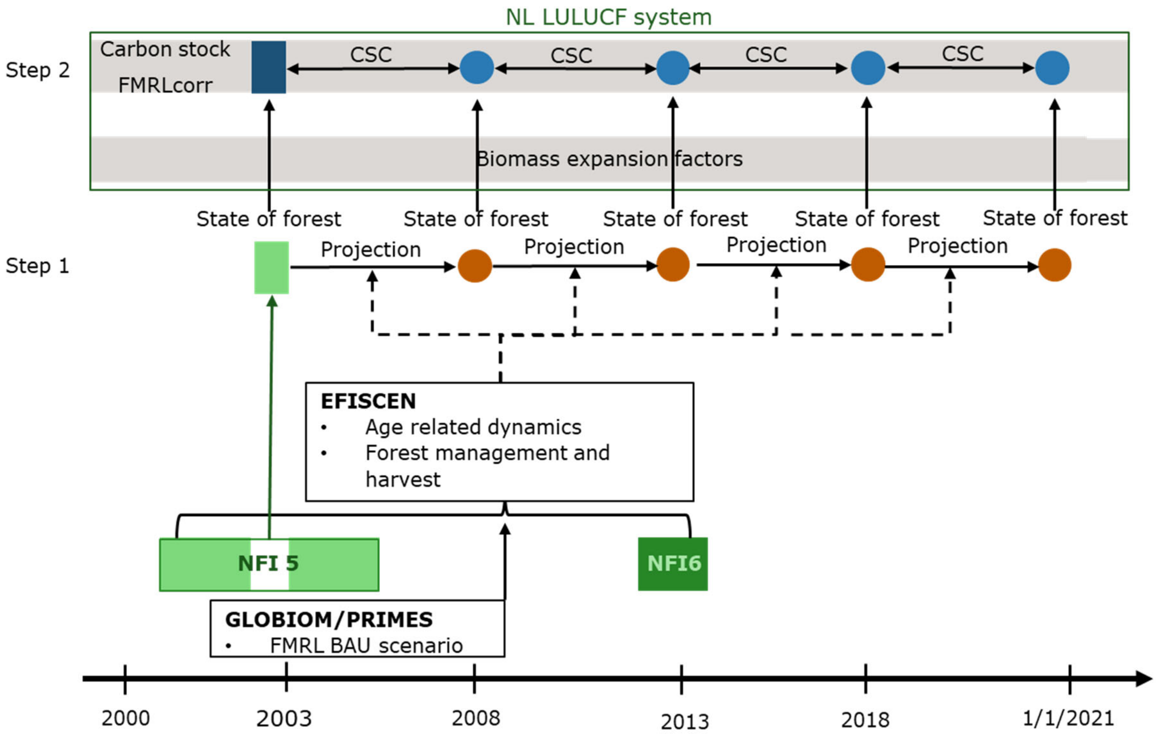

Figure 2.2. *Graphical overview of the approach applied for estimating the carbon stock changes FMRL$_{corr}$. Data from the NFI5 and NFI6 and timber demand from the BAU scenarios of GLOBIOM/PRIMES as used in the construction of the original FMRL are used to parameterise the EFISCEN model. This model then projects average growing stock, etc. as for reporting. Using the same biomass expansion factors these are then converted to average aboveground biomass, belowground biomass and dead wood biomass that is used in the NL LULUCF bookkeeping model to assess carbon stocks and carbon stock changes (CSC). Also see section 4.2.1 in Arets et al. (2021).*

2.2 EFISCEN projections for the $FMRL_{corr}$

The EFISCEN setup as used in the adopted FMRL is based on data from the 5th NFI (NFI-5) in the Netherlands (2001-2005). In the current LULUCF system, EFISCEN is initialized with data from the 6th NFI (NFI-6, 2012-2013), and parameterized based on growth and mortality data as derived from the period between NFI-5 and NFI-6. The input parameters used for the EFISCEN runs used in the assessment of the adopted FMRL are used as a basis for the projections of forest structure for the $FMRL_{corr}$. However, since observed historic mortality parameters changed, these were also updated for the EFISCEN runs for the $FMRL_{corr}$ based on the observations in the period NFI-5 to NFI-6 (cf. Annex 6 in Arets et al. 2021). The data on harvest used in the EFISCEN model and HWP input in the national LULUCF system for the period 2010-2020 are those from the GLOBIOM and PRIMES BAU scenarios as used in the adopted FMRL[6] .

The outputs based on the EFISCEN model that are used as input in the LULUCF bookkeeping model are provided in Table 2.1. As explained below these are used in the same way and with the same data on land-use, land-use change, mineral and organic soils and wildfires as in the regular reporting. Table 2.2 below gives the values of the regular reporting for comparison (same data as in Table 4.2 in Arets et al, 2021).

Table 2.1. *Input on forest biomass used in the LULUCF bookkeeping model for assessing $FMRL_{corr}$. Per NFI inventory and EFISCEN projection output year, its reference year, average Growing stock (GS; m^3 ha^{-1}), aboveground biomass (AGB; tonnes ha^{-1}), BCEF (tonne d.m. per m^3 stemwood volume), net annual increment (NAI; m^3 ha^{-1} yr^{-1}), belowground biomass (AGB; tonnes ha^{-1}), root to shoot ratio (R), share of conifer biomass in the total forest biomass, biomass (tonnes ha^{-1}) of standing deadwood (DWs) and lying deadwood (DWl). The EFISCEN data are based on the $FMRL_{corr}$ model projections as described above.*

NFI	Year	GS	AGB	BCEF	BGB	R	Share	DW Biomass	
							Conifers	DWs	DWl
HOSP	1990	158	112.8	0.714	20.6	0.18	0.44	0.84	0
NFI-5	2003	195	143.2	0.736	25.8	0.18	0.42	1.33	1.53
EFISCEN	2008	215	159.4	0.741	29.3	0.18	0.40	1.52	2.11
EFISCEN	2013	227	167.6	0.739	30.8	0.18	0.40	1.72	2.70
EFISCEN	2018	237	175.5	0.740	32.3	0.18	0.40	1.91	3.29
EFISCEN	2023	247	183.4	0.742	33.7	0.18	0.39	2.10	3.88

Table 2.2. *Input on forest biomass used in the LULCUF bookkeeping model as used in the regular reporting in the NIR 2021. Per NFI inventory, its reference year, average Growing stock (GS; m^3 ha^{-1}), aboveground biomass (AGB; tonnes ha^{-1}), BCEF (tonne d.m. per m^3 stemwood volume), net annual increment (NAI; m^3 ha^{-1} yr^{-1}), belowground biomass (AGB; tonnes ha^{-1}), root to shoot ratio (R), share of conifer biomass in the total forest biomass, mass (tonnes ha^{-1}) of standing deadwood (DWs) and lying deadwood (DWl). The EFISCEN data are based on a model projection, except DW biomass which are based on extrapolation from the period before. The EFISCEN data will be replaced by data from the 7th NFI in the NIR 2022.*

NFI	Year	GS	AGB	BCEF	BGB	R	Share	DW Biomass	
							Conifers	DWs	DWl
HOSP	1990	158	112.8	0.714	20.6	0.18	0.44	0.84	0
NFI-5	2003	195	143.2	0.736	25.8	0.18	0.42	1.33	1.53
NFI-6	2013	222	165.5	0.744	29.9	0.18	0.40	1.97	2.03
EFISCEN	2023	241	182.9	0.758	33.7	0.18	0.39	2.61	2.52

[6] See: https://unfccc.int/files/meetings/ad_hoc_working_groups/kp/application/pdf/awgkp_netherlands_corr.pdf

The data on harvest and HWP input in the national LULUCF system were adapted compared to the period 2003-2007 according to table 14 of the original FMRL submission[7]:

Table 14: Projection of carbon Inflow to the HWP pool

Average of historic harvest (2003-2007) [in 1000m3]	1.204										
Average HWP pool Inflow* (2003-2007) [in 1000t C]	562										
years	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Projected harvest rate [in 1000m3]	1187,98	1184,68	1181,38	1178,07	1174,77	1171,47	1168	1165	1162	1158	1154,95
Change as cp to historic harvest (2003-2007) [in %]	-1,37%	-1,65%	-1,92%	-2,19%	-2,47%	-2,74%	-3,02%	-3,29%	-3,56%	-3,84%	-4,11%
Projected carbon Inflow to HWP pool [in 1000t C]	554,575	553,033	551,491	549,949	548,407	546,865	545,323	543,782	542,24	540,698	539,156

*a similar approach was chosen by Kangas and Baudin (2003): ECE/TIM/DP/30

[7] https://unfccc.int/files/meetings/ad_hoc_working_groups/kp/application/pdf/awgkp_netherlands_corr.pdf

3 Results

The calculated $FMRL_{corr}$ was -1.155 Mt CO_2 eq. per year (average 2013–2020) assuming instantaneous oxidation of HWP and a $FMRL_{corr}$ of -1.065 Mt CO_2 eq. per year applying a first-order decay function to HWP (HWP is an average net source of 90 Gg CO_2). Detailed information for the emissions and removals per carbon pool en emission source is provided in Table 3.1.

Table 3.1. *Projected $FMRL_{corr}$ outputs for carbon stock changes and resulting emissions and removals for the various carbon pools and other emission sources in lands subject to forest management for the period 2013-2020.*

Parameter	Unit	2013	2014	2015	2016	2017	2018	2019	2020	Average
Area	kha	316.7	314.7	312.6	310.6	308.6	306.7	304.7	302.7	
Area mineral soil	kha	302.1	300.3	298.5	296.7	295.0	293.2	291.5	289.8	
Area organic soil	kha	14.6	14.4	14.2	13.9	13.7	13.4	13.2	13.0	
Area org drained	kha	3.4	3.3	3.3	3.2	3.2	3.1	3.1	3.0	
AGBiomass Gain	Gg C	831.7	821.6	811.4	802.3	793.5	775.2	766.1	763.7	
AGBiomass Loss	Gg C	-543.6	-540.9	-538.2	-536.8	-535.5	-534.3	-532.8	-531.6	
BGBiomass Gain	Gg C	51.9	50.5	49.2	47.8	46.4	43.4	42.0	41.8	
BGBiomass Loss	Gg C	NO	NO	NO	NO	NO	NO	NO	NO	
DW	Gg C	24.2	24.1	23.9	23.7	23.6	23.4	23.3	23.1	
Litt	Gg C	NE	NE	NE	NE	NE	NE	NE	NE	
SoilC_min	Gg C	NA	NA	NA	NA	NA	NA	NA	NA	
SoilC_Org	Gg C	-14.1	-13.8	-13.4	-13.1	-12.8	-12.5	-12.1	-11.8	
SoilN2O_min	Gg N_2O	NA	NA	NA	NA	NA	NA	NA	NA	
SoilN2O_org	Gg N_2O	0.0018	0.0018	0.0018	0.0017	0.0017	0.0017	0.0017	0.0016	
Subtotal CSC	Gg C	350.1	341.4	332.7	323.9	315.2	295.2	286.4	285.1	
Subtotal emissions	Gg CO_2-eq	-1284	-1252	-1220	-1188	-1156	-1083	-1050	-1045	-1160
HWP	Gg C	-19.44	-24.84	-30.40	-24.51	-22.51	-25.12	-25.01	-24.89	
HWP	Gg CO_2	71.27	91.09	111.48	89.87	82.53	92.11	91.71	91.25	90
CH4 and N2O emissions from drained and rewetted organic soils										
SoilN2O_org	Gg N_2O	0.003	0.003	0.003	0.003	0.002	0.002	0.002	0.002	
SoilN2O_org	Gg CO_2	0.786	0.774	0.760	0.747	0.734	0.721	0.708	0.696	0.74
Greenhouse gas emissions from biomass burning										
CO_2_FM	Gg CO_2-eq	3.12	3.15	3.18	3.20	3.22	3.24	3.26	3.28	3.21
CH_4_CO_2eq_F_FM	Gg CO_2-eq	0.23	0.24	0.24	0.24	0.24	0.24	0.24	0.25	0.24
N_2OF_FM	Gg CO_2-eq	0.15	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
Total, incl HWP	Gg CO_2-eq	-1208	-1157	-1104	-1094	-1069	-986	-954	-950	**-1065**
Total, excl HWP	Gg CO_2-eq	-1279	-1248	-1216	-1183	-1151	-1078	-1046	-1041	**-1155**

As a result the **technical correction** to be applied to the adopted FMRL is: **+360 Gg CO_2** (details in Table 3.2)

Table 3.2. *Emissions per year (Mt CO_2-eq.) for FMRL and $FMRL_{corr}$ and the resulting values for the technical correction to the FMRL.*

	FMRL	$FMRL_{corr}$	Technical correction
Emissions applying a first-order decay function to HWP	-1.425	-1.065	+0.360
Emissions assuming instantaneous oxidation of HWP	-1.464	-1.155	+0.309

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