Naphtha storage fraction and GHG emissions in the Korean petrochemical industry

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1) Overview

Estimation of carbon emissions related to non-energy use is essential for accurate accounting of national GHG emissions. Carbon emissions due to energy (fuel) use of fossil fuels like petroleum products, natural gas and coal can easily be calculated with readily available carbon emission factors of individual fossil fuels. However, the IPCC guidelines do not provide any method to estimate the carbon storage and release of the petrochemical industry. They only provide default storage fractions for petroleum products like LPG, bitumen, lubricant and naphtha, but not those of chemicals.

Korea has been a large consumer of naphtha as feedstock for petrochemicals. The petrochemical industry processed naphtha in the amount of 47.8 Mt (million tonnes) to produce various chemicals in 2015 (KPIA, 2017). Thus, the amount of carbon emissions associated with the use of naphtha has been significant. Moreover, Korea has been a large exporter of petrochemicals. Following the national boundary principle for emissions (consumption basis) the carbon emission equivalents related to exported chemicals have to be excluded from the Korean emission inventory.

This paper is designed to estimate the Korean naphtha storage fraction for the 2011 to 2015 period as to revise this fraction to be used for the estimation of the annual GHG inventories by the Korean government. The IPCC allows countries to revise their fractions: “Whenever possible, countries should substitute assumptions that represent more accurately the practices within their countries and provide documentation for these assumptions.” (IPCC guidelines, Vol. 3, Energy, p. 1.27).

2) Methodology

The NEAT model estimates CO_2 emissions by subtracting the amount of carbon which is stored in products (chemicals not oxidized during use, abbreviated as NODU) in the carbon flow path from basic chemicals through intermediates to final products. The underlying approach is to estimate CO_2 emissions by fuel combustion, industrial processes, solvent and other product use and waste and can serve as independent comparison for IPCC-SA (Sectoral Approach) (Patel, 2001; Park, 2002, 2005; Neelis et al., 2003). The NEAT model is an independent approach to estimate CO_2 emissions as - unlike IPCC-RA (Reference Approach) and IPCC–SA - it uses production and trade statistics of chemicals. Based on material flow analysis, it is able to estimate accurately carbon emissions and carbon storage. As the NEAT model considers exports and imports of chemicals it is able to estimate CO_2 emissions in line with the national boundary principle (consumption basis) which matches the purpose of emission accounting according to IPCC. The NEAT model can assess not only CO_2 emissions of a country but also the naphtha storage fraction.

3) Results

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The results on the carbon storage and release related to non-energy use of naphtha for the year 2015 are summarized in the table below. Korea produced in 2015 NODU (Not oxidized during use or long-lived products) and ODU (Oxidized during use or short-lived products) products in the amount of 97.149 Mt CO_2 (84.9%) and 17.305 Mt CO_2 (15.1%). Thus, the naphtha storage fraction was 84.9% on the production basis. Furthermore, Korea's net exports of the ODU products were 7.495 Mt CO_2 (6.5%). As the exported ODU products will release carbon in the importing countries, these ODU products can be considered as carbon storage for the exporting country. The carbon storage and the naphtha carbon storage fraction increased to 104.644 Mt CO_2 and to 91.4% for the year 2015, respectively. The naphtha storage fraction was between 91.2% and 93.8% with an average of 92.6% in the 2011 to 2015 period.

Table: Composition of naphtha storage & release for the 2011 to 2015 period

	Production basis eatimates			Consumption basis estimates						
	Production			Consumption			Net exports		Storage	Release
	NODU	ODU	Sum	NODU	ODU	Sum	NODU	ODU		
	(A)	(B)	(C = A + B)	(D)	(E)	(F = D + E)	(G)	(H)	(A + H)	(E)
	[Mt CO_2]	[Mt CO_2]	[Mt CO_2]	[Mt CO_2]	[Mt CO_2]	[Mt CO_2]	[Mt CO_2]	[Mt CO_2]	[Mt CO_2]	[Mt CO_2]
	78.422	10.615	89.037	35.417	5.550	40.966	43.004	5.065	83.487	5.550
2011	88.1%	11.9%	100.0%					5.7%	93.8%	6.2%
	87.802	13.779	101.582	35.676	6.909	42.584	52.127	6.871	94.673	6.909
2012	86.4%	13.6%	100.0%					6.8%	93.2%	6.8%
	88.055	13.460	101.515	40.005	7.000	47.005	48.050	6.460	94.515	7.000
2013	86.7%	13.3%	100.0%					6.4%	93.1%	6.9%
	93.022	16.300	109.322	40.099	9.606	49.705	52.923	6.694	99.716	9.606
2014	85.1%	14.9%	100.0%					6.1%	91.2%	8.8%
	97.149	17.305	114.455	40.996	9.810	50.806	56.153	7.495	104.644	9.810
2015	84.9%	15.1%	100.0%					6.5%	91.4%	8.6%
Average	86.2%	13.8%	100.0%					6.3%	92.5%	7.5%
Notes: NODU means not oxidized during use or long-lived products according to the IPCC terminology.										
ODU means oxidized during use or short-lived products according to the IPCC terminology.										

4) Conclusions

The naphtha storage fraction estimated with the NEAT model was more than 90% for the 2011 to 2015 period in Korea, which is much higher than the IPCC default fraction of 75%. As the naphtha storage fraction will depend on the production and trade structure of a country, it is appropriate for Korea to estimate its own naphtha storage fraction. Korea should revise the naphtha storage fraction from 75% to 90% in its emission accounting. The IPCC allows countries to apply their own values that represent more accurately the practices or their situation (production and trade structure).

Korea's carbon emissions estimated with the IPCC default naphtha fraction of 75% is likely to have resulted in an overestimation of 17.1 Mt CO_2 (15% of the emissions related to the use of naphtha in 2015) or 2.7% of the country's total carbon emissions (about 630 Mt CO_2).

To conclude, a naphtha storage fraction of 90% is proposed as appropriate default fraction for the Korean petrochemical industry. The Ministry of Environment of the Korean government is recommended to account for this finding in their national emission accounting.