External note

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Department Policy Studies

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Subject **Addendum to Refinery Emissions from a Competitive Perspective**

Introduction

Recently, an extensive analysis on the competitive position of the Dutch refineries as a result of stringent environmental legislation has been performed and published in the report 'Refinery Emissions from a Competitive Perspective' (Plomp et al, 2015). This study was performed by ECN and Wood Mackenzie at the request of Netherlands Petroleum Industry Association (VNPI).

Within this study, the impact of costs of various measures both on environmental aspects as well as on risks for major hazards, has been analyzed. A cost burden has been identified for the various measures and is described in Paragraph 5.2 in (Plomp et al, 2015) and this cost burden consists of 766 million EUR_{2010} for Environmental Measures and 562 million EUR_{2010} for Major Hazard Measures. Next to these investment cost burdens, operating costs were identified at a level of 43 million EUR_{2010} for Environmental Measures and 9 million EUR_{2010} for Major Hazard Measures.

The VNPI requested ECN to break down these costs to levels of categorized measures, namely down to the level of pollutant or major hazard category.

Results – Environmental Measures

The costs for environmental measures have been aggregated into various subgroups per pollutant, mainly based on the cost-effectiveness of that particular measure. Calculations for cost-effectiveness were performed in line with the NeR (NeR, 2014). Investment costs were annualized using an annuity factor (or capital recovery factor) of 0.1627, based on a depreciation rate of 10% and depreciation period of 10 years (see also NeR, appendix 4.13). Due to roundings, summations of the subgroups may deviate slightly from the total as provided in the tables. For NO_x-related measures, the results are provided in **Table 1**.

Table 1: *Overview of reduction potential, costs and cost-effectiveness for NO_x-related measures within the Dutch mineral oil refining sector. Subgroups are defined based on cost-effectiveness*

NO_x	Reduction of NO_x (ton/jaar)	Investment (x mln EUR_{2010})	O&M costs (x mln EUR_{2010})	Cost effectiveness (EUR_{2010}/kg)	Band width cost effectiveness (EUR_{2010}/kg)
Subgroup 1	654	34	1	10.3	6.8 – 12.0
Subgroup 2	1500	121	7	17.7	13.1 – 21.5
Subgroup 3	206	37	2	37.8	34.0 – 52.7
Total	**2359**	**192**	**10**	**17.4**	

The results for measures related to SO_2 reductions are provided in Table 2. Within subgroup 3, measures are incorporated that need corrections for actual emission reductions versus its back-ground emission reductions. Therefore, the cost-effectiveness is lower as one may expect based on data in Table 2. Next to this, measures are incorporated which also result in emission reduction of dust. The result of this co-benefit is provided in **Table 4**.

Table 2: *Overview of reduction potential, costs and cost-effectiveness for SO_2-related measures within the Dutch mineral oil refining sector. Subgroups are defined based on cost-effectiveness*

SO_2	Reduction of SO_2 (ton/jaar)	Investment (x mln EUR_{2010})	O&M costs (x mln EUR_{2010})	Cost effectiveness (EUR_{2010}/kg)	Band width cost effectiveness (EUR_{2010}/kg)
Subgroup 1	1127	24	1	4.3	1.4 – 6.8
Subgroup 2	2725	81	10	8.4	7.3 - 11.7
Subgroup 3	2409	198	16	15.9	12.9 - 19.3
Total	**6261**	**302**	**26**	**11.0**	

The results for NMVOC-related measures are provided in **Table 3**. Within subgroups 3 and 4, several measures are included which serve multiple targets, such as reduction of emissions of carcinogenic compound or safety-related measures, next to reduction of NMVOC-emissions. Some measures affect sources, which currently are not part of emission inventories. The cost-effectiveness based on NMVOC-emission reductions is therefore very high for these subgroups.

Table 3: *Overview of reduction potential, costs and cost-effectiveness for NMVOC-related measures within the Dutch mineral oil refining sector. Subgroups are defined based on cost-effectiveness*

NMVOC	Reduction of NMVOC (ton/jaar)	Investment (x mln EUR_{2010})	O&M costs (x mln EUR_{2010})	Cost effectiveness (EUR_{2010}/kg)	Band width cost effectiveness (EUR_{2010}/kg)
Subgroup 1	761	18	1	4.7	0.5 – 8.1
Subgroup 2	1026	76	1	13.0	9.6 – 17.7
Subgroup 3	64	87	2	259	Several measures hardly reduce NMVOC due to multiple targets
Subgroup 4	4	84	2	4437	
Total	**1854**	**265**	**6**	**26.5**	

In **Table 4**, results are provided for environmental measures, which currently do not fall within the earlier mentioned categories. The dust emission reduction in subgroup 1 is regarded as a co-benefit of SO_2-measures. Subgroup 2 represents environmental measures without direct emission reduction, such as the implementation of continuous measurements.

Table 4: *Overview of other environmental measures*

Other environmental measures	Reduction of pollutant (ton/jaar)	Investment (x mln EUR_{2010})	O&M costs (x mln EUR_{2010})	Cost effectiveness (EUR_{2010}/kg)	Band width cost effectiveness (EUR_{2010}/kg)
Subgroup 1	93 ton PM10	*Co-benefit of some SO_2 – measures; data not applicable*			
Subgroup 2	-	7	not relevant		
Total	**93 ton PM10**	**7**	-	-	-

Results – Major Hazard Measures

Major Hazard measures are mainly focused on reducing major hazards at tank terminals. The results for these measures are provided in **Table 5**. The measures have been divided into two categories, namely implementation of impermeable floors and adaptations of bund walls at tank terminals and the other group comprises other measures, including measures to protect tanks for overfilling.

Table 5: *Overview of major hazard measures*

Major Hazard Measures	Investment (x mln EUR2010)	O&M costs (x mln EUR2010)
Impermeable floors and bund walls	339	5
Other measures, including overfill protection	223	5
Total	562	9

Conclusions

In this note, environmental measures and major hazard measures relevant for the Dutch refining sector, have been itemized into various categories with respect to the following parameters: reduction potentials, costs and cost-effectiveness.

Literature

NeR (2014): *Nederlandse emissierichtlijn lucht (NeR)*. Digitale NeR, Augustus 2014. Available via Infomil, http://www.infomil.nl/onderwerpen/klimaat-lucht/ner/digitale-ner/ (last visit October 2015).

Plomp, A.J., P. Kroon, M. Mozaffarian, Ch. Barry, I. McAlpine (2015): *Refinery Emissions from a Competitive Perspective.* ECN-E--15-003, March 10th, 2015.