COMPARISON OF REFINERIES IN DENMARK AND SOUTH DURBAN :
SAPREF COMMENTS ON SIGNIFICANT TECHNICAL INACCURACIES
7 March 2003

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1	Table 3.1.2 – Comparative overview of refineries - Ownership	Operations are 100% Shell	Shell are Sapref's technical advisors, but the refinery is operated 100% by Sapref
2	Table 3.1.2 Comparative overview of refineries – pipelines outside plant	6 pipelines (9km)	Sapref operates a total of 7 pipelines to Island View.
3	Table 3.1.2 Introductory comments	Important to note that data was supplied by the refineries and that the South African data is not independently verified. Where boxes left blank, it indicates that the refineries either did not or could not supply the relevant data	Is Danish data independently verified? SAPREF has no record of these questions being asked. They are not on the spreadsheet (appendix 2). The number of people working in the HSE unit is inaccurate.
4	Table 3.1.2 – Comparative overview of refineries - Complaints	Note 4: Data from SDCEA GIS system on complaints based on Sapref Odour Complaints Report in the absence of Sapref data.	Sapref provided information on complaints from its Continual Improvement System.
5	Fig 3.2.1 – Simplified diagram of primary processes and streams in a Refinery	Diagram showing various process and streams and the connectivity between them. This is referenced in 3.3.4 Basis of Comparison.	Very inaccurate representation of traditional connectivity. As examples, output streams of Alkylation and Reformer are not desulphurised, but their feed streams are. Reformer takes feed from distiller via a hydrotreater, not from Vacuum Distillation.
6	3.3.1 The validity of data	Mistakes are tolerated but manipulation of results is not allowed and has the consequence of	Numerous references and views in report based on inaccurate interpretation/ assumptions of

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		exclusion from the academic community – or at least a bad reputation. … publications subject to peer review in the academic world. See acknowledgements which include academics.	SAPREF operations. Examples include: production of benzene (page 31), sulphur in energy system (page 32, 35), and burning of coke. (pages 37,38,39,40). These and other examples follow.
7	Table 3.2.1 – Danish and RSA quality requirements for liquid fuels		Omission. Table should reflect the gazetted changes in RSA fuel specs from 1.1.2006 (no lead, Petrol and Diesel sulphur down to 500 ppm).
8	Section 3.2.4 – Production - Visbreaker and catcracker	It is therefore necessary to regenerate the catalyst (catcracker) either continuously or periodically.	The catalyst can only be regenerated continuously.
9	Section 3.2.3 – Catalytic Reformer	Instead the aromatics are extracted (the BTX stream) and used for solvents products.	Sapref does not have a BTX plant. Sapref does operate a solvents plant that extracts aromatics from selected feedstock but for the purpose of making low aromatic solvents for sale. The aromatic extract is blended into petrol.
10	Section 3.2.3 – Isomerisation and Alkylation	All four refineries use this type of catalyst.	Sapref does not have an Isomerisation unit.
11	Section 3.2.3 – Isomerisation and Alkylation	The mediator is hydrogen fluoride, HF, which can be substituted by concentrated sulphuric acid.	We presume that “mediator” in this context means “catalyst”. It is not true that the catalyst (HF) in an HF Alkylation plant can be substituted by sulphuric acid. While there are Alkylation plants that have been specifically designed to operate

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			using sulphuric acid as a catalyst, catalysts cannot be swopped across the two designs. An HF plant can only operate on HF.
12	Section 3.2.3 – Sulphur Recovery	The proportion of sulphur recovered depends on the number of SRUs. One unit can obtain 90% efficiency, two obtain 94-96% and three obtain 97-98%.	For this sentence to make sense, the word "reactor" must be substituted for the word "SRUs". In practice, an SRU has a thermal stage (say 65% efficiency) followed by one or more (usually two) catalytic stages (reactor containing catalyst) which will give improved conversion efficiency but at a reduced impact per added stage. Sapref SRUs each have two reactor stages, but the refinery has also added a SCOT unit which improves the overall recovery efficiency of the SRU process to >99%.
13	Table 3.2.3 – Refinery Units and their main products		LPG stream should also be highlighted for desulphurization. In the special comments box, Catalytic Reformer should have Aromatics and iso-hydrocarbons added to text.
14	3.2.4 The Energy System	Refinery liquid fuel systems use heavy fuel oil (HFO) which are produced in the Refinery and can be of different viscosity.	Sapref has removed its HFO loop. The heaviest fuel that can be fired is LFO (atmospheric residue). However, this forms a very small fraction of the total fuel fired (less than 1% for 2001) and is only used

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			in abnormal circumstances. The balance of the fuel fired is gas (99% of total).
15	Table 3.2.4 – Refinery Capacity and production units	Table indicates that Sapref operates an Isomerisation unit.	This is not true.
16	3.2.7 Refineries in an environmental perspective	The physical operating conditions in the various units involve high temperatures and "extreme" pressures.	The word "extreme" gives the wrong impression (negative connotation). While temperatures and pressures are of course much higher than experienced in say the home environment, the facilities are properly designed to operate safely under these conditions. Operating conditions have also been exaggerated (see point 39).
17	3.2.8 Refineries in an environmental perspective- Sulphur Dioxide	The sulphur content in oil ranges from 0.2 to 1.7%.	Statement not clear. If this is related to Table 3.4.1.1, then the text should read "the sulphur content in crude oil processed at these refineries ranges from 0.2 to 1.7%".
18	3.3.2 The data	Sapref is presently installing sulphur dioxide analysers in some stacks. This means that one analysis a year as at Shell will be substituted by continuous measurements.	This statement is completely misleading, implying to the reader that, until on line analysers are installed, Sapref only uses single measurements (once a year) to determine annual SO2 emissions. The SO2 calculation is carried out on a daily basis, and several of the properties (e.g. Sulphur in fuel gas,

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			sulphur in FCCU feed) are measured daily. The H2S content of the tail gas from the SRUs (SCOT unit) is measured continuously by an on line analyzer. It is true that an on-line SO2 analyser will soon be commissioned in the FCCU stack.
19	3.3.2 The data	A leak from one of Sapref's pipelines spilled about 1000 tons of petrol. It has been asked if the refinery should have detected the loss. Annual production (of petrol) is reported as 1 786 100 tons. If the Refinery can report production with that degree of accuracy, it should be able to detect the loss on an annual basis, but provided that the loss has taken place over a long period of time, not on a day-to-day basis.	The refinery balance is calculated as accurately as possible, and is reported in units of kilotons (000's). The input number for petrol production at Sapref for 2001 was 1786.1 ktons. It is not a simple task to close the mass balance, and it is not uncommon to have so called "losses" reported as the balancing number between input (crude and additives purchased) and output (products sold or consumed). Because the refinery throughput is so large, an unidentified loss of as little as 0.1% (not uncommon) amounts to something like 8000 tons in one year (or 8 times the reported size of the petrol leak). It's not to say that 8000 tons is physically lost (it can be overstating crude receipts or understating product sales), it just puts the accuracy of the petrol production and our ability to detect a

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			leak into context. Another aspect is the rate of the leak. As the leak occurred over a period of time, it is much more difficult to detect it. Traditional flow meters don't have the necessary accuracy to determine relatively small leaks (relative to the bulk flow) such as the one experienced.
20	3.4.1 – managing hydrocarbons - Products	Sapref also produced benzene – about a tenth as much as Engen – but it is not visible on the chart.	This is incorrect. Sapref produces Cleaning Benzine (extracted aliphatic solvent with less than 0.1% aromatics) which has been inadvertently reported as Benzene.
21	Fig 3.4.1.4 – Hydrocarbons burned in flares.		Table is incomplete which distorts the comparison.
22	3.4.1. Managing hydrocarbons - Hydrocarbon emissions	Sapref plans to minimize flaring in July 2002 by installing new flare pilots.	This statement is incorrect. The purpose of the new flare pilots is to minimize the chance of the flare pilots being extinguished in high wind, which could result in un-burnt gasses being released to atmosphere.
23	3.4.1.- Managing hydrocarbons - Hydrocarbon emissions	In the data from Sapref, there is complete agreement between input crude and the sum of products. This is a mistake and indicates that the amount of one product is calculated	This statement is incorrect. Sapref accounts for all products independently and then reconciles the balance. If the balance cannot be reconciled, then a loss or a gain

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		as a difference – that is, errors and unknowns have been incorporated into the mass balance.	is reported. From the input data submitted for this report, it is clear that Sapref reported a loss figure which has not been taken into account by the statement in the report.
24	3.4.1.- Managing hydrocarbons - Benzene	The most critical VOC emissions come from where the streams from the reformer are distilled to produce benzene (Engen and Sapref)	Sapref does not distill reformate to produce benzene as a product.
25	Fig 3.4.2.1 and associated text	As none of refineries have installed sulphur dioxide cleaning equipment in the combustion air, the difference must be ascribed to a data error.	If a refinery installed a scrubber to remove SO2, it would be in the flue gas and not the combustion air as stated. Also, it is unclear as to why there is a big difference between the input and emissions from the energy system. Sapref provided the necessary data as requested (input sulphur is correct) and there could be an error by the reporter in generating this graph (output is incorrect). This is an example of where allowing SAPREF view of these graphs and tables before publication may have lead to better understanding
26	3.4.2 The fate of sulphur - Sulphur in the energy system	The first step in reducing sulphur dioxide emissions at all refineries was to substitute refinery produced fuels with a high sulphur content with	Note that Sapref already fires almost 100% gas in the Refinery (input data shows less than 1% liquid fuel in 2001) so this statement is incorrect

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		better quality fuels such as hydrocarbon gases. Even though Sapref has the largest production, it can substantially reduce sulphur dioxide emissions by following this path.	(misleading). Note that coke in the context of refinery fuel is from the FCCU (coke burnt off in the FCCU regenerator to CO and CO2, and the CO then burnt in the CO boiler to CO2, with SO2 generated from the sulphur in the coke).
27	3.4.2. The fate of sulphur - Total sulphur dioxide emissions	In the early eighties, Statoil emitted about 9000 tonne per year, 4000 ton less than Sapref in 2001.	This statement is misleading. The capacity of the relevant refineries and their crude diet goes most of the way to explaining the difference in SO2 emissions.
28	3.4.2.4 The fate of sulphur - Sources of sulphur dioxide emissions	Sapref's total emissions from units dealing with sulphur recovery (SWS, SRU) stands at 4200 tons. Sapref plans to build a new SRU and to substitute heavy fuel oil with fuel gas. These initiatives will save 6000 tonne in sulphur dioxide emissions.	Sapref has already commissioned the new SRU4/SCOT unit (in 2002) and this has reduced SO2 emissions by nearly 50% compared to 2001 levels. Note also that Sapref already fires almost 100% fuel gas, so there is not much scope for SO2 reduction by substituting HFO with fuelgas.
29	3.4.3 Energy – the burning question	They have given the units as MJ but the reported data leads to the assumption that it should be GJ.	Sapref has reported the correct energy consumption as MJ. A slight confusion arose in the tons on fuel fired in the input sheet (text implied that the figures were in 000's tons, which was incorrect).
30	Table 3.4.3.1	Text says original Sapref and Engen data is adjusted by a factor 1000.	The total fuel figure as reported is correct (the original input data spreadsheet had the words "1000 tons" in the text, which was

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			incorrect).
31	Table 3.4.3.1	Sapref fuel numbers show coke being highlighted as a fuel, whereas Engen does not reflect that it burns coke.	Both refineries burn coke (in the catalyst regeneration process associated with the FCCU). It is not a separate solid fuel that is fired. Combustion takes place in the FCCU regenerator. In the Sapref case, the combustion process is not complete, and some CO leaves the regenerator. It is burnt in the downstream CO Boiler to CO2. Engen elect to report their total fuel differently, with coke being included in the total but not reported separately.
32	3.4.3.Energy – the burning question - Energy sources and consumption - Fuels	The refinery has phased out fuel oil but still uses a considerable amount of coke. Sapref thus has considerable room for improving heat energy efficiency.	This statement is incorrect. As explained above, the coke reported in the table is the coke that is burnt off the FCCU catalyst during the continuous regeneration process. There is a brand new boiler downstream (commissioned in 2002 to replace old CO boiler) that recovers waste heat as well as converts the un-burnt CO to CO2 using additional support fuel gas. This process is already very efficient, and there is very little scope for improving heat energy efficiency from burning coke.

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33	3.4.3.Energy – the burning question - Energy sources and consumption – Nitrous oxides	Sapref's data appears not to take account of nitrogen dioxide emissions from coke burning. For complete combustion, coke requires much higher temperatures than gas, implying that emissions from this fuel source are significant.	This statement is incorrect. It stems from the presumption that the "coke" reported by Sapref as being part of the fuel pool is in fact solid fuel (as in coal) fired in a boiler. The coke Sapref refers to is the catalytic coke that is burnt off the FCCU catalyst on a continuous basis in the regenerator. This combustion process is in effect a double system, where part of the carbon is burnt in the regenerator to CO2 and part to CO. The CO is then further combusted along with support fuel in a downstream boiler for conversion of the remaining CO to CO2. This whole process is far more efficient that the author implies. Note also that Engen also burn this "coke" but have not reported coke as a separate fuel in their submission.
34	3.4.3.Energy – the burning question - Energy sources and consumption - Carbon oxides	Sapref's carbon dioxide emissions reflect the larger scale of production, the quality of the crude and its use of coke. This data supports that its nitrogen oxide emissions are under-reported. Carbon monoxide is produced if fuel combustion is complete. Sapref's use of coke is therefore a likely source. The	As per 31 above, the reference to using coke and the fact that it supports under-reporting of NOX is incorrect. Also, as explained above, the carbon monoxide that is intentionally generated by partial combustion of the carbon in the regenerator is converted to CO in the downstream boiler. There has

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		refinery plan to install a new CO boiler at its cat cracker to reduce carbon monoxide emissions. However, its improvement plan does not make clear whether coke is used only at this unit.	always been a CO boiler associated with the FCCU, and a new, replacement boiler was commissioned in 2002. The only “coke” that is fired is in the FCCU regenerator.
35	3.4.4 What the neighbours know - Particulates	Both Sapref and Engen plan to reduce emissions from this source by installing cyclones to catch the particles.	The Sapref TSS (third stage separator) was successfully commissioned in 2002.
36	3.4.4. What the neighbours know - Noise	Noise is a major problem for refinery workers although the focus here is the neighbourhood.	This is an unsubstantiated claim.
37	3.4.5 Miscellaneous – Anti Knocking additives	The need for additives at these refineries results from the refining processes, particularly in those units producing hydrocarbons with high octane numbers. One of these is the Alkylation unit where the South African refineries use hydrogen fluoride.	Contrary to the statement, additives such as TEL are used to counter the impact of the components that have low octane number. Also, HF is not an additive (not added to petrol). It is a catalyst used in the Alkylation unit.
38	3.4.5 Miscellaneous – HF emissions	The chemical is used as a catalyst but is not completely regenerated as can be seen from reported consumption in 2001: Engen 51 ton, Sapref 144 ton. The data for 199-2001 indicates that consumption is falling. But where does the waste go? From the BAT report, it can be deduced that HF goes to the	While it is true that there is a net consumption of acid every year, it is incorrect to state that this material ends up in the waste water system. The majority of HF that leaves the system is in the form of acid soluble oil, which is disposed of separately.

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		wastewater system where it is neutralized with lime and transformed to calcium fluoride ending up in the sludge.	
39	3.4.6 Qualitative conclusions - The comparison of refinery data	The quality of crude oil also results in a high sulphur content in oil products and in emissions from the refineries own energy systems.	The sulphur content of products is set independently (by authorities) and must be met irrespective of the quality of crude being processed. Also, as Sapref burns almost 100% fuel gas, which is treated before combustion to remove sulphur, the emission of SO2 from fuel gas is independent of the sulphur content of the crude being processed.
40	3.4.6 Qualitative conclusions - The comparison of refinery data	The Danish refineries are able to produce petrol of less than 98 octane without additives like TEL or MTBE.	It has been gazetted that South African petrol will no longer be allowed to contain lead from 1.1.2006. All refiners in South Africa are planning to be able to meet this challenge by significant capital expenditure between now and 2006. While some refiners might continue to use MTBE or allied compounds (e.g. TAME), Sapref does not intend to introduce octane boosting additives that are currently not being used in our fuels.
41	3.4.6 Qualitative conclusions- Indicators of good environmental	Sapref's consumption (hydrocarbons burnt in flare) is strikingly high and its plan to address this is	The amount of gas burned in the flare is not strikingly high when compared to the refinery throughput.

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	management.	encouraging.	The comparison is also distorted by the fact that the graph is incomplete (flaring figures omitted from Statoil for all years and Engen for 1999).
42	3.2.3 Production – Visbreaker and cat cracker	The Visbreaker is a non catalytic unit operated at 500 C and at a pressure of <40 bar. In the FCCU, the feed is atomized by steam, the cracking temperature is 500 – 540 C and the pressure < 90 bar.	The cracking conditions in practice are nowhere near as severe as reported (e.g. Visbreaker temperature about 450 C and pressure < 10 bar, FCCU pressure < 2 bar).