Phenosolvan

The results from the sampling campaign provided improved emissions information (including a mass balance across the column) to be used in technical evaluations of potential solutions. With this better emissions information, the technical evaluation of possible solutions will be widened to include technical options that were previously regarded as unfavourable.

A description of the possible solutions is described in the Sections to follow.

- The test run to remove CO_2 to the saturation column verified that the VOCs emitted cannot be significantly reduced by removing CO_2 to the saturation column, and will not be investigated further.
- Flaring to combust the VOC emissions to carbon dioxide: In the 2014 Postponement Application flaring was found to be an infeasible option due to the low heating value and high oxygen content of the stream exiting the saturation columns. The oxygen content was confirmed to be high during the sampling campaign, therefore flaring remains infeasible.
- Liquid removal prior to abatement: Liquid removal from the off-gas stream could be considered to reduce the size of the stream requiring abatement. This option may include condensation of the off-gas, adding a demister to the top of the saturation column or a knock-out pot. The removal of liquid from the off-gas stream, though advantageous to reduce stream size, would not be sufficient on its own to address the full VOC emission reduction required, and additional abatement will be required.
- Membrane separation: Previously, investigations identified that membranes are unlikely to be a feasible option due to the large amount of CO_2 present in the gas stream. CO_2 is a large molecule which will permeate with the hydrocarbons. However, with the new information received from the sampling campaign, the CO_2 content in the off-gas stream is much lower than anticipated, and membranes may be investigated further. This remains a high risk option, as this is an abatement technology that Sasol is not familiar with.
- Catalytic oxidation: Catalytic oxidation creates a significant operations risk, since compounds are present in the off-gas which may render the catalyst used in the process ineffective. On this basis, this solution is considered infeasible.
- Absorption: This technology could be further considered not only for VOC removal but also VOC recovery. However, this technology option would potentially have cross-media environmental impacts, as the absorption medium will be an additional effluent stream that increases the site's waste footprint. Additional waste management solutions will be required. Recycling of the effluent stream can be considered, but is a high risk option, as potential contaminants in the effluent stream may impact negatively on production. The feasibility of this option will be investigated further.
- Adsorption: This technology utilises a high surface area solid adsorbent onto which the VOCs are adsorbed. The adsorbent itself also requires regeneration for removal of VOCs. A waste stream gets generated with this technology which would require additional waste management solutions. Compounds present within the off-gas stream may also render several of the possible adsorbent options used in the process ineffective. This option will be investigated further.
- Condensation: This will be considered in order to recover the VOCs. In order to treat a stream containing VOC components by condensation, low temperatures are required to meet the regulatory requirement, which requires additional energy inputs to the process. This would increase electricity demand for the site, which counters to Sasol's energy efficiency objectives and is therefore seen as a less preferable solution.
- Regenerative Thermal Oxidation (RTO): This option includes the installation of an RTO unit dedicated to Phenosolvan off-gas, or making use of spare capacity (if available) at the RTOs at the neighbouring plants (part of the VOC abatement phase 1 project). The availability of spare capacity for Phenosolvan East VOCs can only be evaluated once another project, Coal Tar Filtration (CTF) East plant, is commissioned, since the emissions emanating from CTF East plant are also routed to the RTO at the Phenosolvan East neighbouring plant.

HOW incinerators

The HOW incinerators currently employ steam flow, pressure control and a trip system to manage PM emission impacts.

SSO's approach to further emission reductions from its incinerators is informed by the waste hierarchy, which places preference on solutions to avoid and reduce waste over disposing of it (to landfill, or to atmosphere, via incineration), since this averts negative environmental impacts. The alternative options evaluated in terms of the waste hierarchy include the following, which would concurrently address the emission components not achieving the MES:

- Operational improvements.
- HOW as an alternative fuel to a 3rd party
- Installation of abatement technology on existing equipment.
- Alternative technologies.
- Installation of a new incinerator.
- Integrated incinerator option
- Reduction of the waste streams being incinerated at source and beneficial utilisation.

It should be noted that landfilling of HOW as an alternative to incineration was not considered as an option, since this will be prohibited by the recently promulgated Standards for Disposal of Waste to Landfill published in terms of the National Environmental Management: Waste Act (Act No. 59 of 2008).

A description of each solution investigated is described in the Sections to follow.

Operational improvements

As described in section 1.3, identified operational improvements have been identified and implemented and have realised some incremental improvements in emissions concentrations, but will not achieve the stringent limits prescribed in the MES.

HOW as an alternative fuel resource

Sasol is investigating with third party support to use the Phenosolvan HOW stream as an alternative fuel resource in the cement manufacturing industry. However, current information indicates that substantial logistics capital investment will be required to transport all the material to the third party. Further work, including an investigation on the feasibility of a separate injection point at a cement kiln, as well as transport requirements, will be done to determine if the option will be feasible.

Installation of abatement technology on existing equipment

The aim of the pre-feasibility study conducted previously and reported on in the 2014 Postponement Application, was to determine the best abatement route on the existing incinerators - only commercially proven technologies were considered in the study, however these have not been proven on the unique waste streams arising from the Sasol process, and hence piloting would be required to demonstrate performance capabilities under all normal operating conditions. Since the postponement decision on the 2014 Postponement Application, this study was expanded to investigate other possible retrofit options in order to operate within the MES requirements, including exit flue gas temperature.

One of the new and potentially more feasible options being investigated is to have a combined abatement unit treating the emissions from the HOW and Biosludge incinerators, which would be

referred to as the SSO waste incineration facility. This option involves some modifications to the current incinerators to reduce the emissions, or replacement with new incinerators, and further emission reduction to occur in a combined abatement unit for both HOW and biosludge incinerators (figure 1 below).

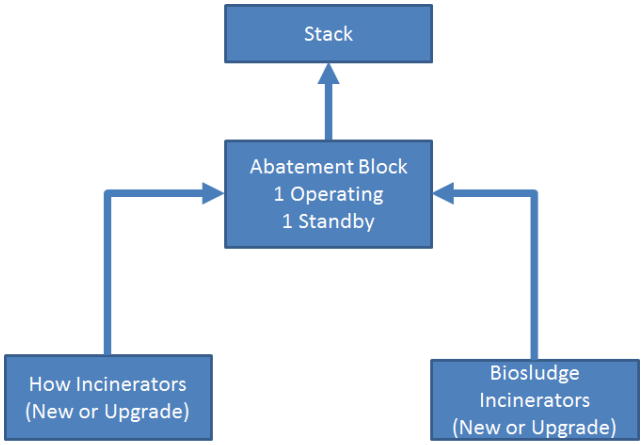

Figure 1: Proposed waste incineration facility

Retrofits to this existing equipment in a brownfields area creates risks of disrupting upstream production, since the total SSO facility cannot operate without HOW incinerator capacity online, as there is no other feasible outlet available for the high calorific value streams it receives and thermally treats. Therefore required modifications and tie-ins would have to be done during planned statutory maintenance cycles of these incinerators, which will require time to implement.

Alternative technologies

From Sasol's technology scanning process, a new alternative technology was identified and investigated (Super Critical Water Oxidation). However, as this is a novel technology with no references to current commercial running plants it poses a high technical risk and will therefore not be considered further.

Installation of new incinerator

Since the previous technology investigation was done which informed the 2014 Postponement Application, a wide range of waste treatment specialist vendors were approached to determine the feasibility to treat the HOW stream. From the vendors who responded that they have technologies to treat the HOW stream, pre-feasibility studies are being undertaken to confirm viability and cost.

Integrated incineration option

An investigation is underway to determine the possible integration of waste streams currently incinerated at Sasol, which would reduce the number of point sources linked to incineration activities. This may include incinerating the combined HOW and biosludge waste streams in one facility, if feasible. The combined stream is proposed to be incinerated and a flue gas treatment facility will be designed to treat off gas to meet new plant standards, including exit flue gas temperature. Some of the waste streams under investigation may come from the Sasolburg Operations complex. However, this investigation is still in early stages, and more consultation within Sasol is required before a decision on viability can be made.

Reduction of streams at source and beneficial utilisation

The feed to the incinerator is made up of a stream from SCO (10-15% by volume) and an SSO stream from the Phenosolvan plant (85-90% by volume). The study investigating the potential for diversion of either of these streams away from the incinerators, by identifying alternative beneficial uses, has concluded that the previous options investigated are not feasible. Further work will have to be done to determine any other unit where the streams can be routed to without negatively impacting the process and product quality.

An investigation is underway in which the Solvents HOW stream can be utilised as a blending component in the heating fuels market. However, placing the product in the market is still in early stages and the customer acceptance is still required before a final decision can be made.

Source reduction of Phenosolvan HOW through improved de-watering at the Ammonia Recovery plant is being investigated, with a planned test trial during the first quarter of calendar year 2017 to confirm the opportunity. Nevertheless, it is known that solutions to reduce volumes of feed streams to incinerators would not practically reduce emission concentrations to the prescribed MES requirements, but would rather reduce the tons (pollution load) of emissions to atmosphere. Since the MES are specified on a concentration basis, reduction in tons of emissions from incinerators, while beneficial for ambient air quality, would not deliver compliance with MES. Concentrations are not always a useful indicator of ambient impacts of a listed activity. Thus, postponements from the concentration-based MES would still be required, aligned with current ceiling emissions concentrations.

Biosludge incinerators

Currently, emissions from the biosludge incinerators are mitigated by Venturi scrubber towers, which reduce concentrations of PM, metals, NH_3, HF and HCl.

SSO's approach to further emission reductions from its incinerators is informed by the waste hierarchy, which places preference on solutions to avoid and reduce waste over disposing of it (to landfill, or to atmosphere, via incineration), since this averts negative environmental impacts and could improve process and energy efficiency. The alternative options evaluated in terms of the waste management hierarchy include the following, which would concurrently address the emission components not achieving the MES:

- Operational improvements.
- Refurbishment of existing equipment and installation of abatement technology on existing equipment.
- Installation of a new incinerator
- Integration of waste streams for incineration
- Alternative technologies.
- Reduction of the waste streams being incinerated at source.
- Landfilling.
- Alternative, beneficial use of the incinerated streams
- Use as Alternative Fuel Resource (AFR) by third party.

This approach was applied to the HOW and biosludge incinerators to identify the most sustainable solution.

Operational improvements

Operational improvements previously identified and implemented by a focused task team, are tracked on a continuous basis by the engineering and operational teams, to ensure sustainable improvements. This includes operating the incinerators in the optimal temperature zones for incineration to ensure a smoother temperature profile with resultant reduction in PM emissions, optimal polyelectrolyte dosage for dewatering of biosludge (prior to incineration). continuously improving the availability of critical equipment, commissioning of a water recovery growth plant which has reduced the total sludge load to the incinerators, and emphasis was placed on quality monitoring of incoming streams. These measures have marginally reduced emissions through optimisation of the operation of the biosludge incinerators. Operational improvements are constrained by the limits of performance of the installed technology, which is operating within its original design intent.

Refurbishment of existing equipment and installation of abatement technology on existing equipment

Previous pre-feasibility work on abatement of biosludge incinerator emissions to comply with the MES concluded that four large projects would need to be implemented at each of the four biosludge incinerators to render compliance: a new centre shaft gearbox; new centrifuges; post combustion chambers; and flue gas cleaning systems. That pre-feasibility work concluded that there was still a relatively high risk that the emissions concentrations would not meet the MES requirements. Given the stringent standards for incinerators, high costs of abating emissions were confirmed by technology vendors to be in line with the costs of installing new incinerators.

Since the decision on the 2014 postponement application, the pre-feasibility study was expanded to investigate other possible retrofit options in order to operate within the MES requirements.

One of the options being investigated (as mentioned in section 1.3.3) is to have a combined abatement unit treating the emissions from the HOW and biosludge incinerators. This will be referred to as the SSO waste incineration facility. This option involves some modifications to the current incinerators to reduce the emissions, or replacement with new incinerators, and further emission reduction to occur in a combined abatement unit for both HOW and biosludge incinerators (figure 2 below).

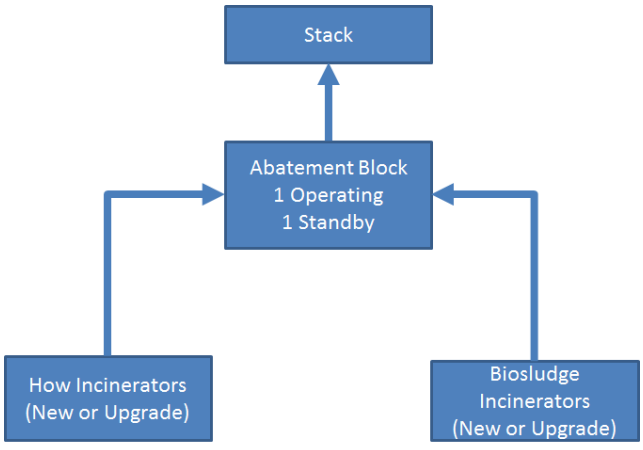

Figure 2: Proposed waste incineration facility

Retrofits to existing equipment in a brownfields area creates risks of disrupting upstream production, since the plant cannot operate without biosludge incinerator capacity online, for management of this continuous stream. Therefore required modifications and tie-ins will have to be done during planned statutory maintenance cycles of these incinerators, which will require additional time to implement.

Installing abatement equipment to comply with the MES for all components would have a high capital cost.

Installation of new incinerator

Previous pre-feasibility work involved investigating the replacement of the incinerators, including a mechanical dewatering section, a fluidised bed incinerator section and a flue gas treatment section. The capital cost of an incinerator replacement is high. Since the previous technology investigation which informed the 2014 postponement application was done, a wide range of waste treatment specialist vendors were approached to determine the feasibility of alternative incinerator technologies to treat biosludge. These are being investigated further in the pre-feasibility phase to determine the feasibility of the application.

Integrated incineration option

An investigation is underway to determine the possible integration of waste streams currently incinerated at Sasol. This may include combining the HOW and biosludge waste streams prior to incineration, if feasible. The combined stream is proposed to be incinerated and a flue gas treatment facility will be designed to treat off gas to ensure compliance to MES requirements, including exit flue gas temperature. Some of the waste streams under investigation may originate from Sasol's Sasolburg Operations Thermal Oxidation plant. However, this investigation is still in early stages, and more consultation is required before a decision can be made.

Alternative technologies

An alternative technology was investigated (Super Critical Water Oxidation), but as it is novel technology with no references to current commercial running plants it poses a high technical risk, it will not be considered further.

Landfilling

Sasol has investigated opportunities to stabilise the total centrifuged biosludge stream using ash, which would enable the waste to be landfilled for a maximum of 15 years after the recent promulgation of the Standards for Disposal of Waste to Landfill under the National Environmental Management: Waste Act.

This option will require a large capital outlay to buy land, build a suitable landfill site and install two large thermal dryer plants, for a limited timeframe before the waste-to-landfill prohibition would be implemented. For these reasons, landfilling was identified as infeasible.

Landfilling with bio-gas harvesting to recover energy is currently being investigated as a potential alternative.

Reduction of streams at source

Since the decision on the postponement application was granted in 2015, the anaerobic treatment plant was commissioned which resulted in a reduction of the volume of biosludge to the aerobic basins, and subsequently to the biosludge incinerators. This reduction does not change the emissions concentrations from the biosludge incinerators, but would rather reduce pollutant loads.

An option is under investigation to treat the biosludge in an anaerobic digester at a third party which will produce methane that can be used for power generation. This can possibly reduce the volume of sludge significantly. A test run is planned at a third party to evaluate viability.

Alternative sludge dewatering technologies were investigated, e.g. mechanical dewatering and thermal drying. These technologies are very energy intensive, however they may reduce the volume of sludge to be treated and reduce transport cost for further treatment by a third party.

Beneficial utilisation

As explained in the section above, pilot investigations into blending and composting initiatives were undertaken, informed by the waste hierarchy. In the 2014 postponement application, SSO indicated that the most promising solution identified at the time was a waste beneficiation solution through composting. Since then, continued testing at environmental impact assessment scale has been undertaken, with disappointing technical results – since the mass balance on metals was not closing. Therefore the composting project was stopped. Alternative methods of composting were also investigated by two universities (North West University and University of Stellenbosch). One of the studies concluded that composting is a potential viable option and additional work will be done.

Reduction in sludge volumes fed to the incinerators would result in a corresponding reduction in total pollution load of emissions dispersed into the atmosphere, but this would not alter the emission concentrations from the incinerators, which is how the MES are prescribed.

Utilisation as alternative fuel resource by third party

Sasol is investigating with third party support to use the biosludge as an alternative fuel resource. The high (90-95%) water content in this stream will require drying before it can be transported to a third party for use. Current information indicates that this will require substantial capital investment. Further work will be done to determine if the option will be feasible.