Responding to the changing Environmental landscape – Using Innovation to drive cost effective solutions

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October 2017
Sasol produces a variety of products from fuels to specialty chemicals
We produce a variety of products from fuels to speciality chemicals

<table>
<thead>
<tr>
<th>MINING</th>
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<tbody>
<tr>
<td>Coal</td>
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<table>
<thead>
<tr>
<th>EXPLORATION AND PRODUCTION INTERNATIONAL</th>
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<tbody>
<tr>
<td>Natural gas</td>
<td>Crude oil and condensates</td>
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<thead>
<tr>
<th>BASE CHEMICALS</th>
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<tbody>
<tr>
<td>Polymers</td>
<td>Industrial solvents</td>
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<tr>
<td>Explosives</td>
<td>Fertilisers</td>
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<thead>
<tr>
<th>PERFORMANCE CHEMICALS</th>
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<tbody>
<tr>
<td>Organics</td>
<td>Inorganics and catalysts</td>
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<tr>
<td>Wax</td>
<td>Phenolics, carbon, ammonia and speciality gases</td>
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<tr>
<th>ENERGY</th>
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<tbody>
<tr>
<td>Petrol and diesel</td>
<td>Jet fuel</td>
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<th>ENERGY</th>
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<tr>
<td>Illuminating paraffin</td>
<td>Propane, butane and liquid petroleum gas (LPG)</td>
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<tr>
<td>Natural gas</td>
<td>Methane rich gas</td>
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<th>ENERGY</th>
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<tr>
<td>Other fuels, lubricants and fuel oils</td>
<td>Bitumen</td>
</tr>
<tr>
<td>GTL fuel products</td>
<td>Electricity</td>
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Why do we produce waste

• Start with coal as a feedstock. Unlike natural gas, this is a complex mix of hydrocarbons, metals, inorganic inert material
• No conversion is 100% efficient – polymerisation and separation process will always result in small amounts of undesired products
• Catalytic conversions come with a finite length in terms of catalyst lifetime
• Even using bioprocesses results in the formation of excess biomass that has to be disposed of
We operate in a rapidly evolving, environmental regulatory landscape

<table>
<thead>
<tr>
<th>NEAR TERM (0-3 years)</th>
<th>MEDIUM TERM (3-6 years)</th>
<th>LONG TERM (&gt; 6 years)</th>
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<tbody>
<tr>
<td><strong>Climate Change Management Approach</strong></td>
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<tr>
<td>Green House Inventories and Reporting Regulations</td>
<td>Carbon Tax Policy White Paper and Carbon Tax Bill</td>
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<tr>
<td>Carbon budgets and /or carbon taxes</td>
<td>Carbon budget review</td>
<td>Carbon budget review</td>
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<tr>
<td>Climate Change Bill</td>
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<td><strong>National Environmental Management Act 107 of 1998</strong></td>
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<td>Environmental offset policy framework</td>
<td>NEMLA 2017</td>
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<td><strong>Air Quality Act 39 of 2004</strong></td>
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<td>Postponement applications</td>
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<tr>
<td>Air quality framework review</td>
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<td>Air quality offset guideline</td>
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<td>Draft strategy to address poor air quality in dense low income settlements</td>
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<td><strong>Waste Management Act 59 of 2006</strong></td>
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<td>Waste Act Implementation</td>
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<td>National Pricing Strategy for Waste management charge</td>
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<td>Industry Waste Management Plans</td>
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<tr>
<td><strong>National Water Act, 36 of 1998</strong></td>
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<tr>
<td>National Water Resources Strategy</td>
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<tr>
<td>National Raw Water Pricing Strategy</td>
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Not exhaustive
We prioritise compliance with all applicable laws, including waste management laws

• We adopt a systematic, hierarchical and risk-based approach to manage and reduce our waste footprint, informed by the waste hierarchy

• We prioritise focus on waste avoidance and minimisation and further recognise some of our waste streams are challenging to handle and require specific disposal solutions

• Our approach is guiding us to limit on-site landfill disposal where practical
  • For a number of streams, we are reliant on both on-site waste disposal solutions (landfill and incineration) as well as third party service provider solutions

• Our technology teams continue to undertake research and development to identify and implement waste management solutions which meet regulatory requirements
The easy way?

Landfill
But….is this a sustainable alternative?

- Waste Act aims to divert waste streams from landfill. Starting with High CV wastes (>25MJ/kg) and becoming stricter and stricter until 2028
- Even for wastes that are permitted for landfill the requirements and costs are high
And that’s not all….

- Landfills have an ongoing legacy management issue
- Require rehabilitation and continuous monitoring
Incineration as an alternative?

- Has the advantage of being a relatively simple, easy to operate process but….
  - Comes at a massive cost
  - Has a large physical footprint
  - Still has a residual waste footprint that has to be managed
  - Produces CO2 and large amounts of wastewater

Typical incinerator
Courtesy: Miller & Spoolman – Living in the Environment 17th Ed
Upsetting the apple-cart

The external environment can easily change forcing plans and roadmaps to be re-evaluated.
Creating a climate for innovation

Pressure + Management support

Multi skilled/diverse teams ↔ Clear goals
Case study 1: Spent caustic

- Current treatment is to incinerate
  - However incineration is very energy intensive
  - In order to meet 2020 NEM:AQA air quality standards extensive retrofitting will be required
  - Retrofitting in a brownfields plant is very expensive and difficult
  - Landfilling prohibition on disposal of liquid wastes
  - Creates a large wastewater stream high in salts
Creating a climate for innovation

Urgent requirement to develop an alternative supported at the highest level in the organisation

Task team made up of operations personnel, microbiologists, chemists, process engineers from different parts of the organisation

Develop a low cost alternative to incineration by mid 2018

Pressure + Management support

Multi skilled/diverse teams

Clear goals
Brainstorming

Initial brainstorming started with 27 ideas

- Daily check-ins with feedback on progress/bottle-necks
- Quickly eliminate ideas with killer concerns
- Robust discussion stimulates new ideas
Eventually the eureka moment comes!

- Sasol’s Secunda operations treat a massive volume of highly varied complex effluents
- Main effluent stream is generated from the Fischer-Tropsch reaction which produces a highly acidic wastewater
- Stream need to be neutralised before treatment
- Bioprocesses can be used to treat a wide range of organics
What if?

- Spent caustic is highly basic
- Organic components are readily biodegradable
- Could the spent caustic stream be combined with the acidic effluent and be treated in a bioprocess?
  - Theory - supports
  - Lab scale toxicity tests – supports
  - Piloting work – supports!
  - Can this practically be implemented? → YES!
Does this approach consistently work?
Acrylate waste case study

• Early in 2017 Sasol faced a challenge with the disposal of an acrylate waste stream
• The waste had bad been handled by a 3rd party waste provider
• Early in 2017, Sasol was informed that due to odour concerns the stream could no longer be processed
Does this approach consistently work?

Urgent requirement to develop an alternative supported at the highest level in the organisation

Pressure + Management support

Task team made up of operations personnel, microbiologists, chemists, process engineers from different parts of the organisation

Multi skilled/diverse teams

Clear goals

Develop an immediate waste handling solution to avoid impacting production
Brainstorming

Initial brainstorming started with 38 ideas

- Daily check-ins with feedback on progress/bottle-necks
- Quickly eliminate ideas with killer concerns
- Robust discussion stimulates new ideas
And once again….Eureka!

90% CH₃OH (aq) → 45% NaOH (aq) → CH₃O⁻Na⁺

1

2: R = OH
R = ethyl

Odourous Acrylates

H₃C-O-CH₂-O-R → H₃C-O-CH₂-O-R → H₃C-O-CH₂-O-ONa

3

4

• With an integrated task team the idea could be quickly evaluated
  • Theory - supports
  • Lab scale toxicity tests – supports
  • Piloting work – supports!
  • Can this practically be implemented? → YES!
This approach yields results!

Our total waste generation has decreased over the past decade

Sasol Group waste generation (kilotons): source SD reports
2005 - 2016

Note: analysis excludes ash which is reported on separately
Enemies of Innovation

Watch out for these

• Beware the bureaucrat and the corporate ‘system’ – easy to stifle innovation. Corporate systems struggle to deal with disruptive ideas. Structures, processes and corporate culture can often work against innovation.

• Absolutely critical to get the team structure correct. Watch out for:
  • “job description”
  • “lone wolves”
  • Negativity - Phrases like – ‘it can’t be done”, “there’s not enough time”, “you’re asking the impossible”

• Get proper buy-in from all stakeholders

• Create a culture where ALL voices are heard. Be wary of a climate of fear.
  • Fear of failure,
  • Fear of making mistakes,
  • Fear of speaking out
We never fail; We either succeed or learn

- Crises brings about heightened energy levels (positive and negative)
- Strong leadership can focus the energy to be channelled in the direction to finding solutions
- Diversity in thinking is the first key to solving complex challenges
- Having a clear common goal is the second key to solving complex challenges
- Strong management support is the third key to solving complex challenges – this unlocks resources, budget, collaboration

“It always seems impossible until its done” - Madiba