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| **From:** | Stacey Davidson |
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| **To:** | Mamosa Africa (mafrika@environment.gov.za) |
| **Cc:** | 'Tsebo Mohapi' |
| **Subject:** | Research and Development Report |
| **Attachments:** | REDISA RESEARCH AND DEVELOPMENT REPORT TO DEPARTMENT OF ENVIRONMENTAL AFFAIRS (2).pdf |

Hello Mamosa

Attached please find the report as requested.

Regards

REDISA NPC
RECYCLING AND ECONOMIC DEVELOPMENT INITIATIVE OF SOUTH AFRICA

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# REDISA RESEARCH AND DEVELOPMENT REPORT TO DEPARTMENT OF ENVIRONMENTAL AFFAIRS

## Background

This report is a follow up request from the minutes of a meeting conducted between the Recycling and Economic development Initiative of South Africa (REDISA) NPC and the Department of Environmental Affairs (DEA) which was conducted on the 16th September 2013. From this meeting there was a sentiment from the DEA that the proposed REDISA research projects have already been performed by institutions such as the South African National Energy Development Institute (SANEDI) and the Council for Science and Industrial Research (CSIR). Hence, REDISA was requested to confer with these institutions the validity of this opinion and thereafter write a report to the DEA in this regard. On contacting the relevant institutions i.e. SANEDI and CSIR, this report details the findings of the request from the DEA.

## Introduction

The REDISA Integrated Industry Waste Tyre Management Plan (IIWTMP) was approved by the South African National Government in July 2012. A revised IIWTMP was gazetted in November 2012. At the heart of this plan is the creation of a new, sustainable industry which will create employment, both for informal and formal sectors, and the fostering of SMMEs and BBBEE. Key to the creation of such an industry is the driving of research and development of smarter and more efficient recycling processes.

The IIWTMP involves a charge to tyre manufacturers of R2.30 (plus VAT) per every kilogram of tyres introduced into South Africa. This money will be used to fund the integrated plan which includes both training as well as research and development (R&D). Both of these can act as drivers for the generation of value from the recycling of tyres.

The plan will gives preference (in order) to processes that:

- produce products of higher quality and value;
- produce products which reduce imports;
- create recycled products for export; and
- create recycled products for local use.

R&D is critical for the success of all such processes, but it is in the first area that it can produce its greatest impact. R&D will be supported by REDISA at South African tertiary institutions to both create and design processes for South African conditions but also to build knowledge and expertise in the country.

REDISA has signed service level agreements with two South African Universities i.e. the Nelson Mandela Metropolitan University (NMMU) and Stellenbosch University (SUN) to

fund research projects at these institutions for a period of five (5) years. The following sections will respectively elaborate the state of research and development for tyre recycling at SUN, NMMU, SANEDI and CSIR.

## Research and Development Areas for Tyre Recycling at Stellenbosch University

The recycling of tyres as a commercial activity is presently dominated by retreading, the production of ground rubber ("crumb") and the use of waste tyres for energy production. Although there is scope to increase such commercial activities in South Africa, the focus of the Redisa research and development program at SUN will be on chemicals recovery from waste tyres, as higher-value alternatives to these established technologies. The major areas of process technologies for this aim will be devulcanisation, as a critical step in the recovery of polymeric substances for re-use in new tyres, and thermal fractionation methods for recovery of chemical building blocks, for use in tyres production as well as other chemical applications. The former is considered to be a larger market, when considering current applications of waste tyres, although significant technical limitations exist. Furthermore, no rigorous comparison of the techno-economics for production polymeric substances vs. chemical building blocks has been undertaken, in comparison to the economic value that can be gained by waste tyres application in crumb and energy production. Hence, a research focus at SUN will also be on such techno-economics studies.

Devulcanisation will be another research focus. Devulcanisation for the recovery of polymeric substances from waste tyres, for re-use in new tyre production, is mostly limited by the relatively poor mechanical properties of recycled rubber that has been achieved thus far. Appreciable enhancement of the quality of recycled rubber will need to be achieved, in order to make recycling of polymers into new tyres technically and economically viable. More specifically, devulcanisation of sulphur-based crosslinking polymers in tyres should be achieved without significant degradation of the carbon-based linkages in the polymeric backbone, which are critical for mechanical properties. Such selective degradation of vulcanised rubber by a wide range of processes is presently under investigation, and will form a key component of the proposed R&D program of the IIWTM plan. More complete thermal degradation of waste tyre material will result in the recovery of monomers, such as styrenes, together with inorganics such as zinc oxide (ZnO), which many consider to be technically more viable than recovery of polymeric substances with the necessary mechanical properties. Examples of process technologies for conversion of waste tyres into polymeric/chemical products would include thermo-chemical-mechanical processing, including the use of chemical catalysis, selective/mild pyrolysis, and other types of thermal fractionation methods. Such thermal fractionation methods will be combined with chemical upgrading and separations technologies, to enable isolation of high value chemical products.

Processes for the recovery of polymeric and monomeric substances from waste tyres will be assessed in terms of economic viability and environmental impacts. Mass and energy balances will be developed for individual process technologies, based on experimental results obtained in laboratory development and available in literature, and will form the basis of techno-economic assessments that will include energy efficiency, economic viability and environmental impacts, through life cycle assessments. Such assessment of processes for chemicals recovery will be done in comparison to existing energy and crumb applications of waste tyres as benchmarks. Gasification followed by chemical synthesis also has the potential for production of high value fuels and chemicals from waste tyres. South Africa is a global industrial leader in gasification-synthesis technologies[1], which will be investigated as alternatives to chemicals recovery for future value-adding to waste tyres.

**Research and Development Areas for Tyre Recycling at Nelson Mandela Metropolitan University (NMMU)**

The NMMU has a long track record of research in the field of rubber science and technology. Furthermore, the NMMU has long been active as a training institution in this field, providing education at both undergraduate and postgraduate levels. At NMMU REDISA is planning to build a Centre for Tyre Evaluation.

Research and development will focus around three core themes:

- The development and application of life cycle assessment methodologies for tyres manufactured and imported into South Africa. Research will ultimately expand into life cycle assessments of processes for the recycling of tyres. The objective here is to ***establish an environmental rating system for tyres***;
- The further processing and application of products, produced from recycled tyres, into higher value products, primarily for use in the rubber, tyre and polymer industries. This will include the use of products, produced by currently available processes, directly in rubber formulations, as well as the upgrading of existing products to other materials;



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Important roles of Fischer– Tropsch synfuels in the global energy future Energy Policy

36 (2008) 2773– 2784, Takayuki Takeshita a, Kenji Yamaji

Current Industry Perspective, Gasification Robust Growth Forecast, World Survey

Results: U.S. Department of Energy, Office of Fossil Energy National Energy Laboratory, Gary J. Stiegel; 2005.

### i) Establishment of an Environmental rating system for tyres

Life cycle assessment/analysis (LCA) is an important tool for the analysis of industrial processes and/or products. When performed in an integrated fashion it provides valuable information about the benefits of a particular process/product when compared to alternative processes/products. Such analysis is not restricted to environmental benefits via environmental impact analyses (EIAs) but also includes the analysis of technical and economic benefits. The latter are themselves not restricted to micro/business level benefits but can be extended to include benefits to society at large through improved employment prospects. LCAs are valuable risk assessment tools. These assessments are important for the development of sound environmental management protocols and for investment decision-making. Life cycle assessment will be used to establish the environmental rating for tyres.

Life cycle assessment work will focus on the environmental, technical, societal benefits and economic benefits of tyre production in South Africa vs. tyres imported from elsewhere. While LCAs for tyre production exist in the USA, these have not been applied in the South African context with its unique location, employment and environmental considerations. Furthermore, the methodologies used are dated and have reduced applicability to modern tyre production.

### ii) Application of products recovered from recycled tyres

Research into the further processing of recycled tyre products will focus primarily on their re-inclusion in rubber and polymer products. An ultimate goal would be to assess the quality of these products for inclusion in tyres. Recovered products to be investigated will include the use of rubber crumb, recovered carbon black, and extractable process oils and reprocessed zinc oxide (ZnO).

In Stage 1 of this process, these materials will be sourced from existing producers of such products, both local and international. Interest has already been expressed by bitumen producer, TOSAS (Pty) Ltd (owned by Raubex (Pty) Ltd), in the development of novel paving materials. The IIWTMP has identified a need to improve the retreading industry in South Africa. Rubber Nano Products (RNP) (Pty) Ltd, a joint venture with NMMU, is already trialling a product, developed at NMMU, in the re-treading industry. Research here will focus on improving retreaded products.

Stage 2 will also tackle the development of processes for the further processing of materials produced from rubber recycling. An example is the conversion of pyrolysis oil to carbon black for re-inclusion in tyre compounds. Conventional processes will need to be modified to accommodate the different nature of the pyrolysis product.

Piloting and demonstration stage production will occur in Stage 3. This work will be performed in collaboration with the Centre for Process Engineering at the University of Stellenbosch, the department of Chemistry at the Qwa-Qwa campus of the University of the Free State, TOSAS (Pty) Ltd and local retreaders.

**Research and Development Areas for Tyre Recycling at the South African National Energy Development Institute**

On consultation with Dr Thembakazi N. Mali, Senior Manager: Clean Energy Solutions; of the South African National Energy Development Institute (SANEDI), to investigate whether SANEDI has done similar kind of research for tyre recycling. REDISA received feedback that SANEDI has not performed any kind of research in this area. However, **SANEDI has in principle included a tyre beneficiation plan in their Waste Hub concept**. The SANEDI waste hub has not been built because of financial constraints. See ***Annexure A*** for the SANEDI Waste Hub concept.

An additional investigative step was undertaken by REDISA to consult the Central Energy Fund (CEF) with the same enquiry and we received a feedback that all research for CEF is conducted by SANEDI.

**Research and Development Areas for Tyre Recycling at the Council for Science and Industrial Research**

On further enquiry with the council for science and industrial research (CSIR); REDISA received feedback from four different directors of CSIR. These are Dr. Douglas Trotter, Competence Area Manager, Green Economy Solutions (Durban), Dr. Bruce Sithole, Director Forestry and Forest Products Research Centre (Durban), Mr. Alan Webb, Project Manager (Rosebank, Cape Town) and Dr. Daniel Visser, Acting Executive Director, CSIR Biosciences (Pretoria). All these conveyed the same feedback message that CSIR has not performed any kind of research in this area; except the fact that CSIR was commissioned by one of the mining companies in South Africa to assist with the establishment of a plant to produce rubber crumb from waste tyres.

**Conclusion**

The intended research funded by REDISA at Stellenbosch University (SUN) and Nelson Mandela Metropolitan University (NMMU) is not a duplication of any research that has been conducted so far in South Africa. It is in some cases an extension of research conducted in the past by these two institutions (i.e. SUN and NMMU).

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***ANNEXURE A***

***(SANEDI WASTE HUB CONCEPT)***