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Sugar Research
Australia

MillingMatters

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Welcome to the first edition of *MillingMatters*



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Published twice a year, MillingMatters has been developed specifically for the milling sector and will profile a selection of the more than 20 milling industry projects SRA invests in.

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In this edition of *MillingMatters* we present a cross-section of projects that address the milling industry issues of how to manage bagasse, optimise the deployment of cane transport systems and improve sugar outputs.

We also profile research which examines how NIR might be used to quantify the nutrient composition of mill mud before and during application to the field. We then take a look at a new life cycle assessment tool that may open opportunities for our industry.

Our industry's future lies with our young and emerging researchers. We showcase the excellent work that some Masters and PhD students are researching that will deliver efficiencies to the milling production process.

MillingMatters is available in hard copy and as an online e-book. If you would prefer to receive this publication via email directly to your desk, please visit our website www.sugarresearch.com.au and select Subscribe to Updates on the home page under the 'Your SRA at work' tab.

SRA is your industry-owned company. If you have any feedback or suggestions about topics that you would like covered in future editions or how we can improve this publication, please let me know by emailing communications@sugarresearch.com.au

Andrew Ward
Executive Manager
Sugar Research Australia

Improving the accuracy of nutrient application with NIR technologies



Eloise Keeffe & Zofia Ostatek-Boczynski

Researcher and Principal Technician

Sugar Research Australia

Near infrared (NIR) spectroscopic methods provide a cost- and resource-efficient technique capable of rapid nutrient quantitation of mill mud, before application on the field.

Because recent reef protection legislation requires more accountability for nutrient inputs in the Great Barrier Reef catchment area, it is important that mill byproducts are able to be included within this accountability framework.

This project aims to develop rapid and easy-to-use NIR-based tools for measuring nutrient elements in mill byproducts.

The tools will enable in-mill analysis of mill mud and, in turn, provide a basis for increased knowledge and environmentally responsible use and distribution.

Limitations of the current byproduct process

Mill byproducts, especially mill mud, are valued for their nutrient content. As a cost-effective nutrient source, their application to crops has been a long-standing beneficial practice for millers and growers.

Historically, transport and logistic costs have limited the application of the product to farms near the mill.

Also, nutrient testing is only sporadically performed on the byproducts and, importantly, never before application.

This approach of applying byproducts to the field at high volumes, without an appreciation of the nutrient loadings, may have resulted in potential over-fertilisation of some elements, especially phosphorus.

How NIR technology can improve on-farm and at-mill activities

If growers know the nutrient and heavy metal contents of mill byproducts, they can reduce their fertiliser costs, more easily adopt precision farming methods, and address social and environmental challenges related to nutrient and heavy metal control.

In turn, by allowing growers to use byproducts within the legislative accountability frameworks, millers can maintain their cost-effective disposal practices. Additionally, there may be the potential to use this technology to value-add to the mill mud and mill ash with other milling byproducts.

Importantly, a better understanding of byproduct composition will allow more-informed legislative action for mill byproduct use in the industry.

What's next?

Over the coming months the validation data collected during recent mill trials will be evaluated to assess the practical viability of the technique.

Research project

Developing measurement tools for nutrients and heavy metals in mill byproducts

Project leaders

Eloise Keeffe

Researcher, Sugar Research Australia

Zofia Ostatek-Boczynski

Principal Technician, Sugar Research Australia

Project end date

May 2014

The release of this technology provides a wide range of benefits to industry, including:

- > a capability of fulfilling legislative requirements for the application of mill byproducts to the field in the Great Barrier Reef catchment area
- > the rapid and cost-effective analysis of nutrient elements in mill mud and mill mud-ash mixture in the milling environment
- > a better understanding of the nutrient profiles of milling byproducts for a specific mill or milling area
- > baseline information on the heavy metal composition in milling byproducts
- > possible future research such as alternative byproduct use, and field-based studies such as leaching experiments, mud decomposition, plant uptake and available nutrient content.

Life Cycle Assessment: Opening the door for eco-efficient opportunities

A new software tool that significantly reduces the time and effort required to undertake detailed life cycle assessments (LCA) will allow the sugar industry to take advantage of the changing and emerging new markets for sugarcane food and energy products.

Market drivers that have created demand for better energy knowledge

Successive federal governments have implemented measures to stimulate more investment in technologies and products to reduce Australia's carbon emissions. These measures include a higher Mandated Renewable Energy Target for renewable power generation and, most recently, the Abbott Government's Direct Action plan. These and other international developments provide major opportunities for the sugar industry as a renewable energy producer.

There is also a rising demand from manufacturers and processors, as well as their investors and customers for information about the life cycle greenhouse gas emissions (carbon footprint) of products.

Organisations such as the Carbon Trust offer internationally recognised accreditation for companies including major sugar retailers that meet prescribed sustainability criteria.

The tool is an EXCEL-based template into which data relating to the production of raw sugar, refined sugar, electricity and ethanol is entered.

Taking advantage of the green economy

Maximising industry's readiness for the introduction of greenhouse gas abatement mechanisms into the economy is essential. This project looks to do this by:

- > defining the carbon life cycle for a range of current and potential industry product mixes
- > providing the industry with a template for life cycle analyses of sugarcane growing, milling, refining and distilling operations for the analysis of individual company operations
- > reviewing current and projected state and federal government policies in relation to opportunities for renewable energy production and carbon trading
- > highlighting the potential carbon trading benefits of integrated sugar milling and renewable energy production.

Identifying the carbon footprint through LCA

This project has developed and demonstrated the use of a software tool that significantly reduces the time and effort required to undertake a detailed carbon footprint, based on LCA, for sugar and energy products from sugar milling co-processes.



Dr Phil Hobson

Queensland University of
Technology

Research project

Opportunities for the Australian sugar industry in greenhouse gas abatement and carbon trading

Project leader

Dr Phil Hobson
Queensland University of
Technology

Project end date

December 2013

The template makes material and energy balance calculations to produce data that can be used to conduct a full carbon footprint using commercially available LCA software.

The tool enables a rapid and consistent LCA evaluation of multiple scenarios relating to farming, harvest and transport practice, factory configuration, co-process integration strategies and the impact of extraneous fuels on the embodied emissions of cane products.

Two contrasting cane production regions and co-processes have been reported as case studies.

The studies were undertaken to provide a demonstration of the model's capabilities and to illustrate the significance of both regional differences and production practices on the global warming potential (GWP) of sugar industry products.

As with previous studies, it was noticeable that between 75 per cent and 80 per cent of the GWP of raw sugar production occurs prior to harvesting the cane.

Regional differences in the overall GWP of raw sugar production occur primarily before the cane is processed. For example, one of the regions studied exhibited significantly higher emissions due to field emissions (nitrous oxide from soil denitrification), irrigation (electricity used for pumping water) and the burning of cane (incomplete combustion) prior to harvest.

In another case study involving a high level of product diversification, the use of coal (to supplement surplus bagasse as a fuel) has a relatively large impact on the overall GWP of export electricity production though a relatively small impact on the GWP of ethanol and refined sugar production.

What's next

This project has been completed and a final report submitted. The intention is that the software will be made available to the industry through QUT on a consulting basis. The consulting fee income would be used to ensure ongoing maintenance and development of the software tool.

Proposed future developments of the tool include:

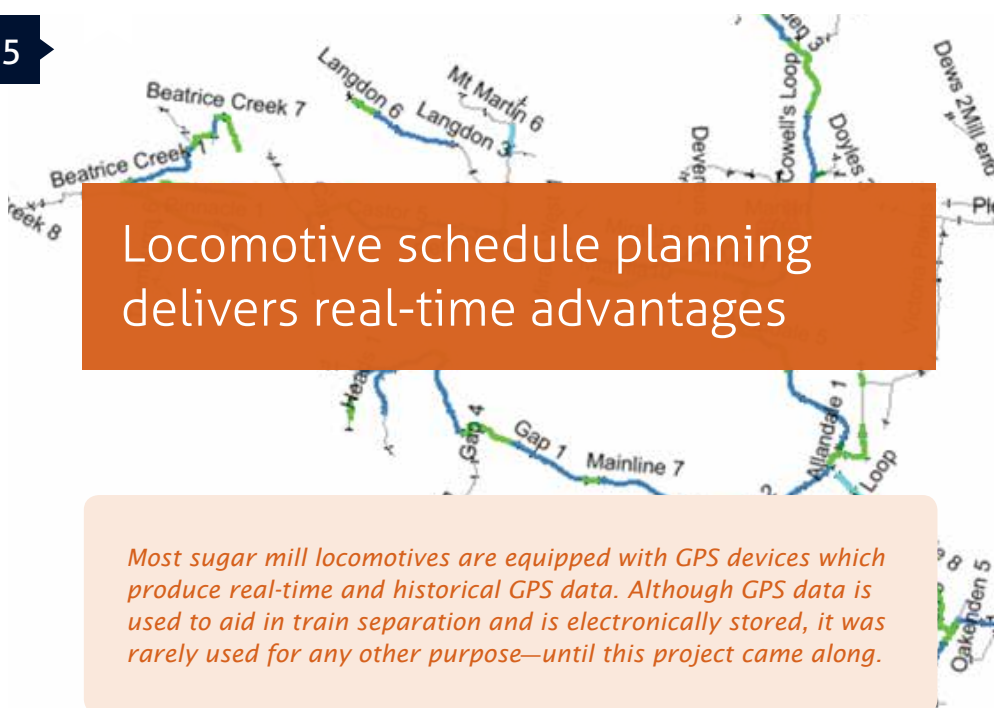
- > an extension of the current first-generation ethanol production scenarios to include lignocellulosic production processes
- > an extension of the LCA tool to include the integration of other crops of interest (such as sweet sorghum) with sugarcane production and processing
- > improved data on soil carbon stocks and fluxes with transformation of land from agricultural cropping to either woodland or pasture and vice versa.

Want to have *MillingMatters* delivered to your desk?

MillingMatters is a new industry resource that can help you keep up-to-date on the research projects that are driving innovation, improved practices and growth opportunities in the milling sector.

The screenshot shows the SRA website interface. At the top, there is a navigation menu with links for 'About SRA', 'Your SRA at work', 'Research capabilities', 'Research funding', and 'Growing cane'. Below the menu is a large banner image of a sugarcane plantation with a red overlay containing the text 'Become an SRA Member before 22 March'. At the bottom of the page, there are several smaller images, and a 'Subscribe to Updates' button is highlighted with a green circle and an arrow pointing to it.

To automatically receive future editions of *MillingMatters* via email, visit the SRA website www.sugarresearch.com.au and click the Subscribe to Updates link.



Locomotive schedule planning delivers real-time advantages

Alex Kono
 Queensland University of Technology

Most sugar mill locomotives are equipped with GPS devices which produce real-time and historical GPS data. Although GPS data is used to aid in train separation and is electronically stored, it was rarely used for any other purpose—until this project came along.

Better locomotive schedule planning

By combining GPS data with loco run activity details that are stored in the Traffic Officer Tools (TOTools) rail operations management software, loco run times can be critically analysed and in real-time, siding arrival times can be predicted.

Real-time data identifies real-time efficiencies

This research project involved two main components. The first part combined historical GPS and TOTools run information data to better analyse time usage in the system. This information will allow traffic officers to identify time wastage that could be overcome to develop more efficient and realistic schedules.

The second part of this project used GPS data in conjunction with TOTools data to predict locomotive arrival time to any siding and mill in the railway network. Using GPS data, rail network and run information, traffic officers will be able to predict when empty bins will be delivered to harvesters or when full bins will be delivered to the mill.

Algorithms added to smart software

The algorithm to analyse loco run time usage was finalised in November 2013 and implemented in the TOTools software.

This algorithm tracks locomotive runs from GPS data and matches them against runs defined in TOTools. The results are then stored in the TOTools database for analysis.

A total of 15 reports to summarise GPS data were developed and added to TOTools. These reports fit into two main categories: to display time information such as run times between locations in the rail network and shunting times at sidings; and to display speed information.

The algorithm to predict siding arrival times has also recently been completed.

Research project

Increasing harvest and transport efficiency through the use of locomotive GPS

Project leader

Alex Kono, Masters project, Queensland University of Technology

Project supervisor

Dr Geoff Kent, Queensland University of Technology

Project end date

August 2014

What's next?

The arrival time prediction software will be tested at Mackay Sugar during the start of the 2014 crushing season.

Loco Name	Date	Driver	Assistant
Loco1	Fri 19/07/13	Driver 1	Assistant B
Sched Start Time	16.30	GPS Time Loco Left Mill	03.23
Actual Start Time	19/07/13 03.32	GPS Time Loco Return	04.21
Finish Time	19/07/13 04.06	Yard time	-00.09
Location	Time	Bin Type	Empties
Farleigh	03.23.52	6T	25
			Fulls
			Duration
			00.00.31
Loco stopped	03.24.23		00.01.00
	03.25.23		
			00.20.42
Leap 5	03.46.05	6T	25
	03.52.39		11
			00.06.34
			00.14.51
Mandurana 6	04.07.30		00.03.33
	04.11.03		
			00.10.24
Farleigh	04.21.27	6T	11
Total	hh:mm	Average	hh:mm
Run duration	00.57	Shunting time	00.05
Shunting time	00.10		
Delay time	00.01		
Travelling time	00.46		

Cane quality: One man's trash is another man's treasure

Since the transition from cutting cane by hand to mechanical harvester, the sugar industry has recognised the problems associated with extraneous matter.

A promising, new, non-pneumatic technology has been developed that overcomes the limitations of current trash removal technologies to get rid of trash more efficiently and effectively.



Chris Henderson

Queensland University of Technology

The importance of removing dirt and trash

Dirt and trash in the cane supply cause significant problems throughout the sugarcane value chain including lower bulk density, which increases transport costs, and lower cane quality, which adds to costs for growers and millers.

Dirt increases sugar losses, reduces extraction and affects process stations throughout the factory, including milling trains, boilers and clarifiers. Trash, especially if high in green leaf and/or tops, delivers increased soluble impurities to the factory, complicating process operations, increasing molasses losses, turbidity and colour.

Current practices that make taking out the trash harder

The trend towards shorter billets, while increasing transport bulk density, also increases the opportunity for sucrose losses via more cuts and damage to the stalk. Some research indicates greater infield losses: more expressed juice at the harvester stage due to more stalk cuts means more sucrose on trash that is ejected onto the field.

Current trash separation or removal technologies rely on pneumatics,

i.e. blowing the lighter leaf litter from a falling stream of heavier cane billets. Installations around the world (and there are only about 27 from over 5000 factories of reasonable size) are large and use copious amounts of energy.

They can also operate only when the cane supply is dry. Importantly, large volumes of dust are entrained in the air, presenting significant barriers to regulatory environmental approval. Cane billet loss can also be significant during separation. These and other factors probably confirm that high capital, operating and regulatory costs have limited the adoption of the technology so far.

A new non-pneumatic technology promises easier trash removal

This PhD project is making great inroads in developing a new technology that operates in both wet and dry cane crop conditions, thereby improving capital use and increasing access to trash and the possibility for better cane quality. Significantly, it:

- > does not use air, which prevents entrained dust and removes environmental regulatory barriers
- > has a small energy requirement relative to pneumatic cane separation technologies

Research project

Improved separation technology for sugarcane biomass recovery and increased renewable energy production

Project leader

Chris Henderson
PhD candidate, Queensland University of Technology

Project supervisors

Dr Phil Hobson, Dr Geoff Kent and Dr Floren Plaza
Queensland University of Technology

Project end date

2014

Project funders

STI scholarship provided by SRA, SRL and QUT

- > has no or insignificant cane loss
- > is able to operate both at the factory gate and infield
- > is mechanically simple and robust to minimise implementation and operational maintenance costs.

To date the technology has no cane loss, does not use any air and separates out up to 91 per cent of available trash with low energy requirements. It operates with both wet and dry cane supply. While in scale-up there are no guarantees, it looks to be a very promising solution.

What's next?

Different factories have different needs. Although Australian needs largely reflect a requirement to improve cane quality, the 'treasure' for some factories or growers will be collecting trash for co-generation, for energy densification and conversion, or for return to the field. A flexible solution that fits the need for each factory or harvested area is another important project requirement.

The project group are planning scale-up work in 2014 and 2015 via partnerships with interested factories, and preliminary activities are already underway. If current outcomes are confirmed, a significant contribution to addressing the problems of cane quality, and a resultant productivity improvement to growers and millers will be made.

Preventing losses during storage of bagasse

Building on work carried out over the last 25 years, this project seeks to achieve a quantitative understanding of the self-heating that occurs within bagasse stockpiles, as well as the gas exchange mechanisms that influence the rate of heating and the resulting loss in fuel quality due to degradation.

Measuring the behaviours of bagasse

The storage of bagasse to fuel the production and export of electricity beyond the end of the cane crushing season is essential to the commercial viability of this activity in the sugar industry. Any losses of bagasse due to degradation or spontaneous combustion can result in significant losses in electricity export revenue. In addition, the self-heating that occurs during the storage of bagasse (or any other biomass) represents a potential hazard for those involved in the physical management of large stockpiles.

An experimental facility has been designed and built to directly measure:

- > flow characteristics, including gas diffusivity and permeability within bagasse, as a function of local compaction, moisture and fibre characteristics
- > exothermic (self-heating) behaviour
- > the rate and products of degradation as a function of local conditions within the stockpile including temperature, moisture, compaction and levels of acidity.

The equipment has been built to measure characteristics that are very specific to the large scale storage of fibrous material. For example, the tests have to measure permeability and

diffusivity (both gas flow characteristics) in two directions. This is because bagasse undergoes compaction (is tamped down) during storage and gas is able to move less readily through the stockpile in the direction of compaction relative to the movement of gas at right angles to the direction of compaction.

What's next?

These measurements have been successful and have produced quality data that has not been available until now. The next step is to feed the data into an existing stockpile software model developed at QUT. The model will be used to design stockpiles and storage practices which minimise the problems of degradation and spontaneous combustion.

Above: Neil McKenzie uses equipment (developed as part of the project) to measure the rate of gas diffusion through bagasse.

Dr Phil Hobson

Queensland University of Technology

Research project

Biomass characterisation facility for extended stockpile model accuracy and capability

Project leader

Dr Phil Hobson, Queensland University of Technology

Project supporters

Neil McKenzie, Dr Floren Plaza, Dr Laleh Moghaddam, Dr Chris East and Adrian Baker
Queensland University of Technology

Project end date

2014

Improving sugar outputs for better marketability

The importance of reducing colour and ash levels in sugar is well known and continues to be the subject of much work in the sugar industry around the world.

However, due the impact of a range of macro factors, new technologies, in particular those that are environmentally effective, are sought to improve the sugar output.

To respond to this challenge, a syndicate of Queensland mills commissioned this project to examine options to reduce sugar colour and ash by adding hybrid coagulants during clarification.

Current processes and the need for change

There are three reasons why transformational technologies are sought that reduce impurity loadings, particularly colour—the tightening of economic circumstances; varying sugar quality produced from the use of different sugarcane cultivars; and increasing competition in the world sugar market.

For Australian sugar to maintain and improve its marketability, it must find these technologies.

Apart from the crystallisation process, there are few alternatives to current processes that can significantly and economically reduce raw sugar colour—except for the use of sulphur dioxide.

However, the use of sulphur compounds for decolourisation is discouraged in many countries because of the health risks surrounding the consumption of sulphur-contaminated sugar.

The promise of hybrid coagulants

Preliminary results from this trial show that hybrid coagulants can improve raw sugar colour and ash significantly without affecting pol, and without a major financial investment.

Specifically:

1. The use of selected coagulants has the potential to improve sugar quality. In the normal clarification process, a hybrid coagulant (100 ppm) significantly reduced raw sugar colour by >60 per cent and ash by 50 per cent. There was also some reduction in polysaccharides.
2. The potential cost of implementing the technology is \$3-\$4/tonne of raw sugar, depending on the additive selected. If bulk quantities of the additive are made, it is expected that the cost will be reduced.
3. There is no pol loss.

What's next?

The next step is to demonstrate the use of the hybrid coagulants



Professor William Doherty

Queensland University of Technology

Research project

Development of technologies for the production of low sugar colour

Project leader

Professor William Doherty
Theme Leader Processing
Chemistry, Queensland University of Technology

Project end date

March 2014

identified in the study to reduce raw sugar colour and ash. The technology has the potential to be used in the phosphatation of raw sugar to produce white sugar, without significant capital investment.

The technology complements the normal clarification process and only a tank and pump would be required to deliver the coagulant to mixed juice prior to liming.



Above: The melanoidin/phenolic mixture before treatment (left) and after treatment (right).

Managing disruptions within harvest and transport systems



Dr Arthur Pinkney

Queensland University of
Technology

Cane harvest and transport systems suffer frequent disruptions. To alleviate this problem, a real-time scheduling system (RTSS) has been designed and built to provide an instant scheduling tool for traffic officers, thereby allowing them to focus on the key safety requirements of keeping trains separated. As significant advancements in the project have now been made, future work will focus on expanding the system.

Efficient transport schedules reduce harvester delays

RTSS models both the harvest and transport of cane, and uses the available resources—locomotives, locomotive shifts, bins—to produce efficient schedules even when disruptions, including mill stoppages and delays to locomotive runs, are considered.

RTSS builds its locomotive runs by repeatedly addressing the traffic officer's operational question:

'There are this many bins in the mill yard and at the harvesters. What should I do with the locomotive that's now in the mill yard?'

RTSS combines a number of these purpose-built locomotive runs to produce a complete schedule.

For the mill studied in the development of the RTSS, the primary purpose of the large majority of locomotive runs within the crucial harvesting period of each day was to maintain the supply of empty bins to the harvesters.

For this mill, RTSS reduced harvester delays to between 1 per cent and 2 per cent of the total available harvester time.

When harvester delays in the system are directly included, the harvesting sector reaps the benefits.

The benefits of an RTSS

- > **Safety in the harvest and transport system. Traffic officers are free to concentrate more on safety issues.**
- > **Reduced mill stoppages caused by cane supply shortages.**
- > **Reduced harvester delays caused by problems with the supply of empty bins.**
- > **Better maintained harvest and transport costs, even when disruptions occur.**



Research project

Real-time harvest and transport system

Co-supervisors

Dr Arthur Pinkney and Dr Geoff Kent
Queensland University of
Technology

Project end date

July 2014

Recent advancements in RTSS development

Significant recent advances have been made in this project, including:

- > RTSS being used to create schedules for additional mills
- > RTSS being expanded to consider locomotive passing
- > the establishment of a steering committee, consisting of mill transport managers to guide the development of RTSS.

What's next?

A three-stage program seeks to deliver a commercial RTSS for traffic officers as an instant scheduling tool. The stages are:

1. Producing and critically examining complete pre-season schedules for specific mills.
2. Using RTSS to produce tomorrow's schedule—the schedule that is prepared for or by the traffic officers for tomorrow's actual operations. These first two stages demonstrate that RTSS can produce acceptable schedules and, thereby, build confidence in the system.
3. Building a decision support system that allows traffic officers to use and interact with RTSS.

Funding is currently being sought to complete these stages.

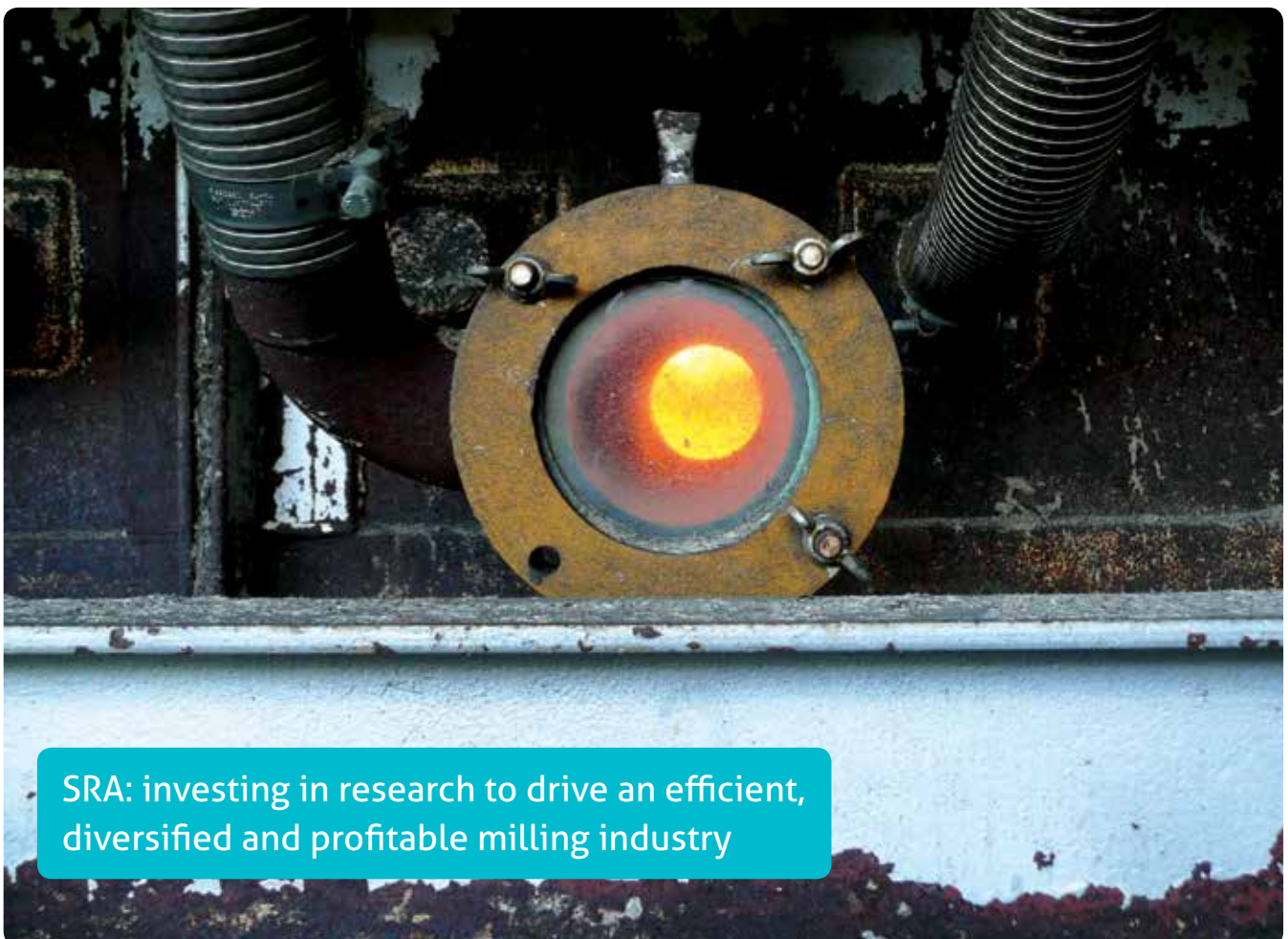
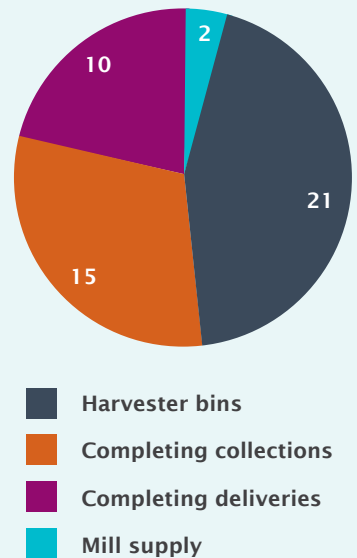
The first two stages will be focused on in 2014 with the goal of:

- > expanding RTSS to handle more of the characteristics and constraints of the real-world cane harvest and transport system
- > improving the data used by RTSS by capturing any available GPS/ GIS data
- > generating tomorrow's schedules for at least one mill.

Right: RTSS runs are designed to keep the mill supplied with cane, to keep harvesters supplied with bins and to ensure that all harvester bins are delivered and collected.

This project received financial support from a syndicate of Australian milling companies for a period of one year. Prior to this period, the development work was unfunded and conducted as Arthur Pinkney's PhD project.

The reasons why RTSS builds its runs



SRA: investing in research to drive an efficient, diversified and profitable milling industry



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