Final report: Industry priorities for value add & diversification opportunities in the sugar industry

Abstract
This report contains the summary of outcomes of SRA Project 20180104 "Establishing a strategic roadmap for product diversification and value addition"

Eris O'Brien & Tony Campbell

Lazuli Consulting
Preface

This report could not have been written without the help, expertise and brainpower of a large group of people. We therefore would like to express our thanks to:

- Dr Michael O’Shea and Dr Harjeet Khanna for their advocacy for this project and for trusting us to run this process.
- The members of the Industry Reference Group, who helped us in our endeavours by asking the right questions; thank you Prof. Ian O’Hara, Burn Ashburner, Mark Moriarty, Dr Dianne Glenn and Hywel Cook.
- The team on this project, primarily Tony Campbell – Principal Consultant at Lazuli Consulting, Dr Dianne Glenn – Principal, Corelli Consulting, Dr Mark Harrison – Senior Research Fellow, QUT, and, Dr Stephen Cox – Director, QUT.
- The long list of consultation participants who provide frank and informative views on value add and diversification. Your contribution to this report, and the overall industry view contained herein cannot be underestimated. Thank you.

Special thanks are given to SRA and the Queensland Department of Agriculture and Fisheries (DAF) for their support and investment for this project.

SRA also acknowledges the co-investment from the Australian Government Department of Agriculture towards this research activity.

Notwithstanding all this help and all the efforts, we made to complete and be precise in our research and reporting, the responsibility for any omissions or errors in this report lie solely with the authors.

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This report was prepared by Lazuli Consulting

Eris O’Brien – Managing Director – Lazuli Consulting

Tony Campbell – Principal Consultant – Lazuli Consulting
Executive Summary

This project was developed to assist Sugar Research Australia (SRA) is advancing its efforts to deliver on its 2017/18 – 2021/22 Strategic Plan with a research project on Key Focus Area 6 (KFA6) product diversification and value addition.

The objective of the project was to better understand industry views on value adding and product diversification and develop a list of agreed prioritised diversification opportunities that may require further RD&A activity or market analysis.

This process was assisted by targeted consultation with industry stakeholders including peak body organisations, milling companies and others to inform potential opportunities for consideration within the prioritisation process.

The methodology used for the study was:

1) Peak bodies and an Advisory Panel were consulted to confirm the scope of the consultation process and seek introductions to key industry figures for consultation.
2) A background brief was developed to provide industry participants with information for discussion prior to the consultation session.
3) Consultation sessions were held with key representatives from CANEGROWERS, milling companies and other key industry stakeholders. A total of 27 sessions were held.
4) The results were compiled, analysed and presented in this report.

There are significant resources available to the sugar industry, not all of which are used for value add and diversification activities.

The following shows the 2017 mass balance for feedstock, products and by-products.

### 2017 Sugar Industry Mass Balance

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Unit</th>
<th>Approx. t / ha</th>
<th>Industry quantity</th>
<th>Industry revenue $'Million</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>On farm</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cane trash</td>
<td>Mt</td>
<td>12.5</td>
<td>4.70 Mt</td>
<td>-</td>
</tr>
<tr>
<td>Cane billets</td>
<td>Mt</td>
<td>88.4</td>
<td>33.34 Mt</td>
<td>1,356</td>
</tr>
<tr>
<td><strong>SUB TOTAL</strong></td>
<td></td>
<td></td>
<td>100.9</td>
<td>38.04 Mt</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1,356</td>
</tr>
<tr>
<td><strong>At mill</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raw sugar</td>
<td>Mt</td>
<td>11.87</td>
<td>4.48 Mt</td>
<td>1816</td>
</tr>
<tr>
<td>Molasses</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Export</td>
<td>Mt</td>
<td>2.63</td>
<td>0.53 Mt</td>
<td>72</td>
</tr>
<tr>
<td>Ethanol distillation (approx.)</td>
<td>Mt</td>
<td>0.23 Mt</td>
<td>31</td>
<td></td>
</tr>
<tr>
<td>Other (approx.)</td>
<td></td>
<td>0.25 Mt</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td>Mud &amp; boiler ash</td>
<td>Mt</td>
<td>5.34</td>
<td>2.02 Mt</td>
<td></td>
</tr>
<tr>
<td>Waste water</td>
<td>GL</td>
<td>56.11</td>
<td>22.0 GL</td>
<td>-</td>
</tr>
<tr>
<td>Bagasse</td>
<td>Mt</td>
<td>12.4</td>
<td>4.67 Mt</td>
<td>-</td>
</tr>
<tr>
<td>Export energy</td>
<td>GWh</td>
<td>n/a</td>
<td>1,770 GWh</td>
<td>191</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td></td>
<td></td>
<td>2,137</td>
</tr>
</tbody>
</table>
Beyond physical commodities, other resources of interest in value add and diversification include:

- The area of land under cane is 377,000 Ha.
- Mills are a good central location where feedstocks are co-located with land, electricity, a skilled workforce, steam and an electrical connection.
- Feedstock logistics can be made available during the non-crush, including:
  - 4000 km of rail
  - 250 diesel-hydraulic locomotives
- Offtake logistics for bulk commodity handling are in place with the 6 sugar export terminals
- 487 MWe electricity generation capacity (excluding the Tablelands cogeneration upgrade).

The opportunity was also taken to document the framing issues as identified by industry participants. To industry participants, these matters were of importance and necessary for SRA and other stakeholders to understand diversification and value add. These are captured in this document to provide guidance to SRA and other stakeholders as to the issues underlying the trend to value add and diversification, as well as other issues of importance to the industry to provide some context.

At the outset of this study it was assumed that industry would have preferences for specific products, such as a type of biochemical. The original scope for this project proposed that the top 5 chemicals or products from this first stage consultation process would be further documented, with technoeconomic analysis, literature reviews and development of roadmaps for research and development in a second stage.

However, the outcome of the consultation process was instead focused on market issues, and a handful of known value add opportunities, with little focus on individual products. The discussion was commercially based and reflected the deep experience with value add and diversification with industry over recent decades.

The two top topics related to value add and diversification were for a market watch and a complementary technology watch. This reflects the industry view that there are no shortage of opportunities and the industry will invest when they think they can make a profit. The market and technology watch services could help reduce uncertainty about projects and investments.

The full list of value add and diversification topics raised by industry, in no particular order, is:

1. Market watch
2. Technology watch
3. Sugar as a food product
4. Cogeneration
5. Industrial ethanol
6. Densified biomass (bagasse & trash)
7. Chemicals from sugar
8. Chemicals from biomass
9. Rum and other spirits
10. Energy cane
11. Sweet sorghum
12. Fallow year crops
13. Fibre crops  
14. GMO, transgenic plants and synthetic biology  
15. Animal feed  
16. Tops and trash  
17. Biogas, biomethane and renewable hydrogen  
18. Knowledge provider

Considerable discussion was held on framing issues for the sugar industry, including the following top three topics. These were discounted from inclusion in the recommendations for SRA as they are not value add and diversification opportunities, however, they strongly reflect the priorities of industry in improving their sustainability and profitability.

- Harvest losses/mill gains – while there are genuine questions and improvements to be made, these are mostly already covered under other key focus areas within SRA. Given that this was the most discussed opportunity and also the topic with the widest range of views, there appear to be further opportunities for SRA to put this issue to rest.
- Farm systems/ BMP uptake – an area of concern to industry but is covered under other key focus areas (KFA) of the current 5 year strategic plan.
- Knowledge provider/consultant – this would appear to be mostly covering company specific issues rather than industry wide priorities. The knowledge held by SRA on the topics of value add and diversification are valuable, but likely in relation to specific opportunities rather than industry wide opportunities.

**Recommended Industry Priorities for SRA**

<table>
<thead>
<tr>
<th>Industry Priorities</th>
<th>Potential SRA role</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Market watch</td>
<td>Knowledge. Already suggested in the SRA 2017/18 – 2021/22 Strategic Plan. Provide a useful offering to industry. Commodities to be determined.</td>
</tr>
<tr>
<td>2 Technology watch</td>
<td>Knowledge. Use existing contacts in industry – publish curated and collated updates.</td>
</tr>
<tr>
<td>3 Densified biomass (pellets, briquettes, etc.)</td>
<td>Process research. Potential for targeted research on treatment, pelletisation/extrusion, and dehydration processes in order to reduce capital and operating costs. The role of complementary crops could be included in research.</td>
</tr>
<tr>
<td>4 Food products – value adding to the sugar itself.</td>
<td>Product development. Helping meet market needs. From fundamental research to helping develop products for end users. Could also cover agave and sweet sorghum sugars.</td>
</tr>
<tr>
<td>6 Complementary crops (Sweet Sorghum, Agave)</td>
<td>Complementary crop development. Help industry select varietals, develop farm management systems, develop food products and supporting processes, identify and quantify mill modification requirements, plus processes for producing non-food products (ethanol, cogeneration, densified biomass). Techno-economic analysis of the whole system.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Secondary priorities</th>
<th>Potential SRA Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 Chemicals from sugar</td>
<td>Process research. Market watch and technology watch could help keep industry informed. From fundamental research to...</td>
</tr>
</tbody>
</table>
An interesting outcome was the lack of specific opportunities in 2\textsuperscript{nd} generation technologies which use biomass as a feedstock. Based on the consultation sessions and our industry knowledge this can be interpreted as industry participants recognising the high level of technical and market risk attached to these processes, which was expressed as a desire for help with the market watch and technology watch services from SRA.

Fallow crops are of interest but don’t rate as a top priority, largely as fallow crops are already being pursued across industry. The issues raised were about the need for infrastructure such as processing plants and storage, to improve the viability of those crops.

The risk attitudes of industry are informative. We asked participants about the scale of opportunity they were interested in, and also attitudes towards 3\textsuperscript{rd} parties. The results, which are indicative only, are as follows.

Figure 13 – Industry Risk Attitudes

Regarding the scale of opportunity, both views make sense. The industry has investigated numerous opportunities in the past with very little actually being confirmed as viable, and no game changers identified. Taking an incremental approach could be sensible, taking smaller bets, and achieving as much additional revenue as possible. On the other hand, the amount of organisational time and effort dedicated to smaller projects could be considered costly and putting those same resources into larger projects could be considered a rational decision.

The results of this consultation suggest that the industry would like to do projects themselves, and are, pragmatically, asking for the market and technology watch services from SRA in order to help them remain informed of when opportunities arise in the future.

There was little interest by industry participants in SRA researching new products or processes. There was recognition that hundreds of millions of dollars are being spent in the bioeconomy with some 900 or so companies seeking to commercialise their technology and
products. There was also recognition that the industry would like assistance in the near term and that the 8-15 year timeframe for commercialisation did not match their needs.

On a related point, the potential for SRA to seek international collaboration was raised as a means for SRA to leverage its funds as best as possible.
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1. Overview & Methodology

PROJECT OVERVIEW

“Establishing a strategic roadmap for product diversification and value addition” - SRA Project 20180104

This project was developed to assist Sugar Research Australia (SRA) is advancing its efforts to deliver on its 2017/18 – 2021/22 Strategic Plan with a research project on Key Focus Area 6 (KFA6) product diversification and value addition.

The objective of the project was to better understand industry views on value adding and product diversification and develop a list of agreed prioritised diversification opportunities that may require further RD&A activity or market analysis.

This process was assisted by targeted consultation with industry stakeholders including peak body organisations, milling companies and others to inform potential opportunities for consideration within the prioritisation process.

The original scope of this project also included an optional stage to provide opportunity analysis and reporting, the intention of which was to take the five top industry priorities, appoint recognised lead researchers for each, and provide a more comprehensive analysis. The outcomes were expected to be a detailed literature review, technoeconomic analysis, market overview and development of roadmaps or suggested R&D programs. It was decided that the consultation stage of the project would be completed first and that SRA reserved the right to seek a more comprehensive review on understanding industry priorities.

Industry stakeholders, SRA, government and universities are frequently approached to support research in value adding opportunities. Not all research in value added products will, however, lead to good commercial outcomes. SRA and its stakeholders need to be able to filter which pathways will most likely lead to valuable, sustainable market opportunities and so direct the limited industry RD&A funds to the most appropriate activities.

The results of this study define a strategy context-based industry consultation within which SRA can optimally target its limited RD&A resources to address industry diversification and value addition.
METHODOLOGY OF THE STUDY

The direction given for this study was that given the multitude of value add and diversification opportunities available to industry there was a lack of consensus as to where SRA should focus its efforts in RD&A as views amongst stakeholders vary considerably.

Over the course of developing the proposal for this project, working with SRA, the following process was adopted.

1) Initial consultation with peak bodies and key stakeholders to ensure that the scope of the project and consultation was acceptable. Meetings were held with CANEGROWERS, Australian Sugar Milling Council (ASMC), Australian Cane Farmers Association (ACFA) as peak bodies. A meeting was also held with the Queensland Department of Agriculture and Fisheries (DAF) as co-founder of the study and the Queensland Department of State Development, Manufacturing, Infrastructure and Planning (DSDMIP) as the custodian of the Biofutures Queensland Policy.

Key feedback included:

- Acknowledgement that the consultation process could look at initiatives which may benefit growers alone, with the caveat that any initiative would not take cane away from the mills, as that would be detrimental to the viability of the mills.
- Alternative crops, such as sweet sorghum and agave were also found to be possible points of discussion.
- Prior failures may have led to a view that some pathways and products won't work, whereas, those same products may be viable in the future.
- Efforts need to be market driven.
- The lack of a clear industry wide vision.
- Social license to operate issues around public perceptions of sugar and also issues relating to the Great Barrier Reef were seen as important.
- A strong focus on what is possible in the near term.
- The cane payment formula was raised as being important, with discussion around how different parties should benefit. There was also a strong view that the formula could be better dealt with when an opportunity arises rather than worked on in advance as a topic for research by SRA.
- Policy risks. For example, regarding the Queensland State Government, Biofutures Queensland was raised as a positive, but legislation around the Great Barrier Reef was seen as a negative.
- Who is SRA is researching for? If it takes 10 years to develop a value add opportunity, will there be ongoing vertical (miller side) and horizontal (grower side) integration in cane growing? Will the ownership of mills change again? No particular answer was provided other than the comment that opportunities should help the majority, and it wasn’t possible to help everyone.
- Perceptions of Australia being a world leader in sugar innovation may no longer be true with a lot of innovation being led by Brazil, Thailand, India and other sugar producing countries.
- Industry sees value add and diversification as one side of the equation when it comes to sustainable increased revenues for industry. The other side is improvements in harvest and transport.
This feedback was provided to SRA and agreement was reached as to inclusions in the scope, and topics that could be discussed.

2) An industry reference group was established with representatives from the milling side, growers and value add and diversification.

The remit of the Industry Reference Group was to:
   a. Use their knowledge and experience to guide the project team as to what industry stakeholders require information or updates on as part of the background brief.
   b. Advise on how to constructively engage with the industry as a whole.
   c. Provide referrals and suggested contacts for the consultation process.

The Industry Reference Group consisted of:
   • Professor Ian O’Hara – Principal Research Fellow, QUT Centre for Tropical Crops and Biocommodities.
   • Mark Moriarty – Manager Business Development, Wilmar,
   • Dr Dianne Glenn – Principal, Corelli Consulting,
   • Hywel Cook – GM Business Development, MSF, and
   • Burn Ashburner – Senior Manager Industry – CANEGROWERS.

It was recognised from the outset that it was only possible to contact and consult with a selected few industry participants, and the Industry Reference Group provided guidance as to whom we should include in the consultation process in order to have a reasonably representative range of views.

3) The project team developing the background brief was informed of the advice of the Industry Reference Group, and chapters were allocated to those with the best expertise.

The team developing the background brief consisted of:
   • Eris O’Brien, Managing Director, Lazuli Consulting
   • Tony Campbell – Principal Consultant, Lazuli Consulting,
   • Dr Dianne Glenn – Principal, Corelli Consulting,
   • Dr Mark Harrison – Senior Research Fellow, QUT, and
   • Dr Stephen Cox – Director, QUT.

The chosen theme of the background brief was to look at the typical project risks looked at in a typical business case and try and bring out of that discussions on what decision makers would need to consider and how SRA could help de-risk those decisions through its RD&A efforts.

The chapters of the background brief were:
   a. What it takes to get a project to financial close
   b. Resources available to industry
   c. Update on products and processes – Dr Mark Harrison - QUT
   d. Markets – Dr Dianne Glenn, Corelli Consulting
   e. Policy environment – Dr Stephen Cox, QUT
   f. Scaling up, and
   g. Case Studies – Dr Dianne Glenn, Corelli Consulting
A website, SugarValueAdd.Info was also developed to capture some of the detailed background information not included in the background brief document.

4) Consultation Process

The Background Brief (attached in Appendix B) was sent to consultation participants, along with a letter of introduction from SRA to update them and inform discussions.

Meetings were held in the period October to December 2018 at times suiting participants given their availability at the tail end of the 2018 Crush Season.

Detailed meeting notes were taken, and it was acknowledged in writing that discussing value add and diversification opportunities during consultation sessions may broach commercially sensitive or confidential information. The premise of the interviews was that the meeting notes would be treated as confidential by Lazuli Consulting and SRA and will not be attributed to any individual or organisation, or provided to any party, other than those involved in the consultation process, without the explicit prior consent of all relevant parties.

5) Analysis and reporting

The detailed notes of the meetings were used as a basis to develop an industry prioritised list of value add and diversification opportunities.

The initial view of priorities was provided to SRA management and Board, as well as key representatives from ASMC, CANEGROWERS and ACFA.

At the outset of this study it was assumed that industry would have preferences for specific products, such as a type of biochemical. The outcome of the consultation process was instead focused on market issues, and a handful of known value add opportunities, with little focus on individual products.

The analysis of these opportunities, including the methodology to shortlist priorities for SRA under KFA6 is provided later in this document.

The opportunity was also taken to document the framing issues as identified by industry participants. To industry participants, these matters were of importance and necessary for SRA and other stakeholders to understand diversification and value add. These are captured in this document to provide guidance to SRA and other stakeholders as to the issues underlying the trend to value add and diversification, as well as other issues of importance to the industry to provide some context.

ABOUT THIS REPORT

The following chapters of this report contain a concise description of the consultation process results.

The report starts in the next chapter (chapter 2) with a general description of the resources available to the industry, covering off existing products, co-products and markets.
Industry issues framing value add and diversification (chapter 3) are captured to provide an overview of the diversity of issues and views on those issues on contextual matters in which value add and diversification activities are considered.

A summary of views on specific value add and diversification opportunities (chapter 4) covers the key views and diverse range of views for those opportunities. A much greater suite of opportunities was raised in the background brief than are discussed in this chapter, however, the opportunities included are those actually discussed.

The level of interest and breadth of interest in specific opportunities were assessed using a methodology developed to provide an industry-wide priority list for KFA6 Value add and diversification (chapter 5).

Chapter 6 contains a summary of the outcomes and recommendations for the consideration of SRA and its stakeholders in determining the focus of RD&A activities relating to KFA6.

Appendix A provides a detailed list of consultation participants.

Appendix B presents the Background Brief as provided to participants of the consultation process. The information provided was intended to be a snapshot of value add and diversification and related issues, in order to provide a common basis for discussion.
2. Context / Resources

This survey represents a snapshot in time, and as such, the specifics of the industry and sugar price at the time of the consultation would have informed the responses of the industry participants to one degree or another.

The following represents a snapshot of the industry context, as well as an overview of the resources available for value add and diversification activities, as well as activities already underway.

STUDY CONTEXT

Essentially, this study presents an interpretation of responses received from individuals, groups and organisations as representatives of the Australian sugar industry. By extension, the study also engaged with groups, individuals and parties external to the industry but with vested interest in the study outcomes.

The consultation process therefore included farmers, growers, grower associations, milling executives, milling associations, academics and various government agencies.

In conducting the interviews, on a best endeavours basis, the authors moved the conversation away from immediate headline based thinking to a bolder new world.

The context was narrated as an industry beyond the interviewees retirement. In retrospect, the authors are of the view that they succeeded and indeed, achieved a conversation away from immediate headlines.

Nonetheless, framing the context within which the many interviews were conducted is useful in interpreting the responses received.
SUGAR PRICES

The prevailing sugar prices at the time of the study in the second half of 2018 were the lowest in 10 years. While prices have somewhat improved since then, the imperative to improve industry returns was clear.

Figure 1 – Recent Sugar Prices

The Australian industry has been assisted to a degree by a relatively weak Australian dollar compared to the US dollar, the currency in which the futures contracts are struck.

One of the key concerns in the market was India’s intentions with respect to its surplus stockpiles created due to a bumper crop and favourable growing conditions in major producing countries.

RELATED MATTERS IN THE SECOND HALF OF 2018


2. MSF was concluding its significant investment in 25 MWe co-generation facility. At the time of interviews, construction was nearly complete with early stage

 https://www.quandl.com/search?query=AUD%20USD


commissioning and testing scheduled for commencement early in 2019. This was the only significant project underway at the time of this review.

3. Mackay Sugar announced a term sheet had been established with Germany’s Nordzucker with respect to its recapitalisation.

4. Growers were very concerned about ever increasing costs, in particular, power prices. Aside from the relentless escalation of costs, growers were uncertain as to future prices given the proposed phasing out of existing tariff structures.

5. Proposed Great Barrier Reef preservation regulations changes proposed in 2018 culminated in the Queensland Government’s Environment Protection (Great Barrier Reef Protection and Other Legislation Amendment Bill 2019. At the time of consultation, several participants expressed frustration at what they perceived as scientifically un-founded policy with respect to the Great Barrier Reef.

6. The Biofutures Queensland team of the Queensland Department of State Development, Manufacturing, Infrastructure and Planning was noted to be working with the sugar industry as the major source of feedstock for biofutures technologies.

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8 Environment Protection (Great Barrier Reef Protection Measures) and Other Legislation Amendment Bill 2019, Queensland Parliament website.

RESOURCE MAPPING

The potential of value add and diversification opportunities available depend on the resources available. Sufficient quantities of feedstock are required to meet the economies of scale needed by many processes in order to be competitive in their respective markets.

Figure 2 – Schematic of the Sugar Industry Supply Chain and Resource Flows

The current indicative industry mass balance assembled as input to this review is summarised below, and is based on ASMC 2017 statistics:
### Table 1 – 2017 Sugar Industry Mass Balance

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Unit</th>
<th>Approx. t / ha</th>
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<tbody>
<tr>
<td><strong>On farm</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cane trash$^{10}$</td>
<td>Mt</td>
<td>12.5</td>
<td>4.70 Mt</td>
<td>-</td>
</tr>
<tr>
<td>Cane billets$^{11}$</td>
<td>Mt</td>
<td>88.4</td>
<td>33.34 Mt</td>
<td>1,356</td>
</tr>
<tr>
<td><strong>SUB TOTAL</strong></td>
<td></td>
<td></td>
<td>100.9</td>
<td>38.04 Mt</td>
</tr>
<tr>
<td><strong>At mill</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raw sugar$^{11}$</td>
<td>Mt</td>
<td>11.87</td>
<td>4.48 Mt</td>
<td>1816</td>
</tr>
<tr>
<td>Molasses</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Export$^{12}$</td>
<td>Mt</td>
<td></td>
<td>0.53 Mt</td>
<td>72</td>
</tr>
<tr>
<td>Ethanol distillation$^{13}$</td>
<td>Mt</td>
<td>2.63</td>
<td>0.23 Mt</td>
<td>31</td>
</tr>
<tr>
<td>Other (approx.)</td>
<td></td>
<td></td>
<td>0.25 Mt</td>
<td>34</td>
</tr>
<tr>
<td>Mud &amp; boiler ash$^{14}$</td>
<td>Mt</td>
<td>5.34</td>
<td>2.02 Mt</td>
<td>-</td>
</tr>
<tr>
<td>Waste water$^{14}$</td>
<td>GL</td>
<td>56.11</td>
<td>22.0 GL</td>
<td>-</td>
</tr>
<tr>
<td>Bagasse (dry basis)$^{14,15}$</td>
<td>Mt</td>
<td>12.4</td>
<td>4.67 Mt</td>
<td>-</td>
</tr>
<tr>
<td>Export energy$^{16}$</td>
<td>GWh</td>
<td>n/a</td>
<td>1,770 GWh</td>
<td>191</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td></td>
<td>2,137</td>
<td></td>
</tr>
</tbody>
</table>

Beyond physical commodities, other resources of interest in value add and diversification include:

- Land under cane is 377,000 Ha.
- Mills are a good central location where feedstocks are co-located with land, electricity, skilled workforce, steam and an electrical connection.
- Feedstock logistics can be made available during the non-crush, including:
  - 4000 km of rail
  - 250 diesel-hydraulic locomotives
- Offtake logistics for bulk commodity handling are in place with the 6 sugar export terminals
- 487 MWe electricity generation capacity (excluding the Tablelands cogeneration upgrade).

Key identified resource flows are discussed below.

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$^{12}$ UN Comtrade Database, www.comtrade.un.org, accessed November 2018


$^{16}$ Clean Energy Regulator (‘CER’) public register data identifies circa 1.26 million certificates registered by sugar mills during the calendar year 2017. Including CER defined baseline allocations totalling 510,00 MWh’s, approximately 1,770,000 MWh of electricity was exported to grid in CY2017. Valuations assumes a MWh bundle price of $107.90/ MWh.
MILL MUD & BOILER ASH

Sugarcane press mud is the residue of the filtration of sugarcane juice. It contains soil from the sugarcane that enters our mills, sugars and bagasse particles and lime, which is used in the clarification process.

The clarification process separates the juice into a clear juice that rises to the top and goes for manufacture, and a mud that collects at the bottom. The mud is then filtered to separate the suspended matter, which includes insoluble salts and fine bagasse.

Ash is the material that remains after the combustion of fuel (largely bagasse) in mill boilers.

These beneficial by-products are combined and distributed over farms as an organic soil conditioner and an important source of plant nutrient.

However, the continued application of mill mud at high rates, without appropriate recognition of its nutrient content, the soil condition, crop nutrient requirements, slope of the land, or proximity of application sites to environmentally sensitive areas has raised a number of concerns in recent years, including over fertilization, heavy-metal contamination, leaching, and off-site impacts from drainage to waterways (Qureshi et al, 2001).

The volume of mill mud generated is depends on several factors. Harvest conditions and methods are significant drivers of soil content gathered with cane billets. Qureshi et al (2001) suggest sugar mills generate from 0.02 to 0.06 tonnes of mud for each tonne of cane crushed.

BAGASSE

Bagasse is the pulp left over after juice has been extracted from sugarcane, sugar beets, sorghum stalk, or agave. Basically, once the juice has been squeezed from stems, leaves, or fruits, the mills are left with a mixture of fibrous plant debris similar to wood pulp.

Recent studies by SRA have shown that the fibre content of cane received and measured at the mill can vary widely, with the Isis Mill measuring fibre content at between 10% and 22% over the period 2009-2017 (Kent, 2018). For this report a value of 14% fibre content has been assumed as a global value to provide high level numbers. This equates to 280 kilograms bagasse per tonne of cane billet harvested, on a 50% moisture basis.

Australia’s sugar industry has used bagasse to meet its electricity and heat requirements for over 100 years. Indeed, bagasse historically was the bane of the milling industry encouraging the industry to consume energy inefficiently in order to dispose of all bagasse produced.

Today, in-mill bagasse fired boilers and generators produce energy which can be exported to the broader electricity network. In 2017, the industry exported approximately 1,770 GWh of electricity representing approximately 3.1% of Queensland total electricity generation for that year, and 5% of the Renewable Energy Target.

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18 Kent, G.A.; Parfitt, R.C., 2018, Reviewing and extending knowledge of fibre quality assessment within the SRA breeding program to develop optimally adapted varieties for the Australian sugar industry, Sugar Research Australia.
In 2017/18 some 9.7 million tonnes (50% moisture basis) of bagasse was produced from 31.1 million tonnes of sugar cane\textsuperscript{19}. ASMC studies\textsuperscript{22,19} indicate that should more efficient boilers be installed and steam on cane settings be improved, 1.7 million tonnes of bagasse could be made available for electricity generation or uses in other processes.

Additional bagasse can be made available, should it be economic, through growing higher fibre cane varieties (known as ‘energy cane’), or supplementary sources such as Sweet Sorghum or Agave.

**CANE TRASH**

Historically, pre-harvesting cane fields were burnt to reduce the amount of vegetation matter gathered during harvest. Today, most cane is harvested green and the residual cane trash is returned to the field for its inherent agronomic values, viz: nutrient recycling; soil conservation; soil health and moisture retention.

Around the world, a portion of the cane trash is collected for sale to feed mills, while freshly cut green tops are sometimes collected for farm animals. In most cases, however, the residues are burned or left in the fields to decompose.

The challenge to otherwise valorise cane trash is finding the optimal point between agronomic value and alternative use taking into account gathering logistics.

Assuming a recovery of 12.5 tonnes of cane trash and tops per hectare\textsuperscript{20} and 377,000 Ha land under cane, there are some 4.714 million tonnes of trash and tops available as a theoretical maximum. Converting to energy content at 17 Gigajoules per tonne\textsuperscript{21} (high heat value) the energy content available is some 80 Petajoules.

Using cane trash as feedstock for 2nd generation fuels is not new. The challenge is determining the percentage of trash to retain so that in-field agronomic benefits (moisture retention; weed control; nutrients; sediment management) of trash is not compromised. This will vary by region.

**MOLASSES**

Molasses\textsuperscript{22} is the thick syrupy residue left over after the sucrose has been removed from the clarified sugar juice (syrup). The ‘C’ molasses (final or blackstrap molasses) is used for alcohol fermentation, as a stock feed supplement and as a fertiliser for cane fields.

The estimated molasses yield per 100 tonnes of harvested cane is 3 to 7 tonnes of molasses. At 3 tonne molasses per 100 tonnes of cane crushed, indicatively, the industry currently produces approximately 1 million tonnes of molasses per annum valued at ~ A$130M. Molasses produced is either exported, consumed as feedstock for the Sarina distillery or sold as an animal feed supplement.

\textsuperscript{19} Personal Communication with David Rynne -Director Policy, Economics and Trade, ASMC, 23 April 2019.
\textsuperscript{22} Sugarcane Molasses, Feedipedia: Animal Feed Resources Information System, https://www.feedipedia.org/node/561
As per the chart below, approximately 600 thousand tonnes of molasses were exported in 2017 realising A$75 million in 2017.

**Figure 3 – Historical Molasses Revenue - Australia**

![Historical Molasses Revenue - Australia](chart.png)

**Waste Water**

Approximately 70% of sugarcane, by weight, is water, which is largely evaporated into the atmosphere to recover sugar, with some ending up as part of the bagasse burned to create steam. Run of mill bagasse is approximately 50% moisture.

**Cogeneration**

Australian sugar mills are energy self-sufficient. Requisite energy is generated using conventional biomass fired boilers to deliver both process steam powering mill trains and shredders as well as low pressure steam for evaporators, and steam to drive turbo generators producing electrical energy. Most mills export electrical energy to the national electricity market (‘NEM’) whilst export of steam is by and large limited to refining operations.

Collectively, mills combust circa 4.67M tonnes of bagasse (dry) per annum in boilers notionally delivering around 84.5 PJ of energy\(^23,24\).

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\(^{24}\) Note: The background brief quoted this as 56PJ, which was mistakenly calculated using a value of 12kJ/kg (dry basis).
Table 2 – Cogeneration Capacity and 2017 Calendar Year Production

<table>
<thead>
<tr>
<th>Region</th>
<th>Capacity (MW)(^{25})</th>
<th>2017 REC(^{26})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southern QLD</td>
<td>73</td>
<td>120,074</td>
</tr>
<tr>
<td>Herbert – Burdekin, QLD</td>
<td>172</td>
<td>443,581</td>
</tr>
<tr>
<td>Mackay Proserpine, QLD</td>
<td>110</td>
<td>178,231</td>
</tr>
<tr>
<td>Northern QLD</td>
<td>67</td>
<td>190,024</td>
</tr>
<tr>
<td>NSW</td>
<td>65</td>
<td>328,173</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>487</strong></td>
<td><strong>1,260,083</strong></td>
</tr>
</tbody>
</table>

In-mill energy is predominantly thermal energy, transported as steam, and the balance electrical energy. Of course, each mill’s energy consumption, volume and composition, will be different.

Moreover, noting that the industry historically operated inefficiently to dispose of otherwise worthless bagasse, there are many examples and publications identifying opportunity to significantly improve and valorise energy efficiency within the industry.

A recent industry study commissioned by ASMC showed that improving electricity production efficiency as measured by MWh electricity per tonne of bagasse from 0.2 to 0.4, should increase the amount of electricity generation from 1.1 million MWh per year to 3.3 million MWh per year\(^{27}\). If steam on cane settings were improved, an additional 1.7 million tonnes of bagasse (50% moisture basis) would be available per year, equating to an additional 602,000 MWh per year generation. Combining both improvements could technically provide a total of 4 million MWh per year.

Figure 4 – Historical electricity revenue for the sugar industry

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\(^{27}\) Personal Communication with David Rynne -Director Policy, Economics and Trade, ASMC, 23 April 2019.
**KNOWN OPPORTUNITIES FOR VALUE ADD AND DIVERSIFICATION**

Value add and diversification have been goals within industry for decades. The following schematic shows the various known categories of opportunities and how they relate to the industry supply chain.
Figure 5 – Value add & Diversification Opportunities in the Sugar Industry Value Chain
3. Industry issues framing value add and diversification

Industry participants raised a number of common issues which they considered in any discussion about the industry in relation to value add and diversification.

While not directly value add and diversification topics themselves, these framing issues are detailed in this chapter as industry felt that SRA and other stakeholders misunderstood the industry when singling out value add and diversification opportunities to the neglect of the overall industry landscape.

These topics have been captured here to best inform the reader about the industry.

**SUSTAINABLY INCREASING PROFITS**

This consultation process was focussed on value add and diversification opportunities. However, from a financial point of view, it is only one part of the profit equation.

Within the current sugar production value chain, the high-level options are:

1. Increase yields on the farm - more cane and sugar to the mill both increases saleable sugar and by-products, and also reduces the long run marginal cost per unit of sugar sold.
2. Reduce costs for growers - improving their viability. For example, lower irrigation costs through use of solar PV power, reduced fertiliser/pesticide costs, reduced labour costs through autonomous vehicles, and other use of new data driven technologies.
3. Reduce in-system losses - reduce harvest losses of cane juice, improve mill process yields, selectively harvesting the highest CCS cane when mature, etc.
4. Increased economies of scale for growers - More efficient use of equipment and labour. Allows for investments that reduce costs over time, e.g. solar PV installation, fertigation.
5. Increased asset utilisation - reducing capital costs and potentially labour costs, in turn lowering the long run marginal cost of production. Examples include 24/7 harvesting using less harvesters, supplementary crops to extend mill operations into the non-
crush. Reuse of farming/harvest/transport assets for non-sugar crops. The use of larger 2-3 row harvesters could be an example of this too as higher yields are produced per dollar of cost (capital and operating) of the harvester.

6. Value add and diversification - further transforming or processing existing products/co-products so they can be sold at a higher price, as well as using different feedstocks or making different products.

To growers and millers, all the above are of interest, and were discussed. Reducing harvest/transport/milling losses was considered something that could be done almost immediately.

Improving yields per hectare was the next most commented on topic, with much discussion held on the perceived low uptake of farming best management practices.

Several participants pointed out that there is only a limited amount of money left on the table were the existing sugar value chain to be optimised, however, bigger gains were to be made in new revenue streams such as cogeneration, ethanol and other new products.

**SHARING THE PIE**

For those outside the industry the need for growers and mill owners to work together seem obvious. However, the following spectrum of views will come as little surprise to anyone in industry.

| There is no industry. There are people with access to capital, and there are those who don't. |
| Whoever makes the investment should make the returns. |
| If growers aren't profitable, then mills close down." (from a miller) |
| Every extra tonne of cane we can get at the mill, the better. We need good growers. |
| The cane payment formula - as written - strikes a good balance between miller and grower and their inherent motivations. |
| The cane payment formula has already been changed at certain mills to add on other products. |
| What happens if there is a move to more fibre, such as energy cane? |
| What happens if a third party establishes a biorefinery at the mill? |

This last question is potentially interesting as developing new technologies often means taking a lot of technical, market and financial risk.

As a challenge, how should the industry consider sharing the pie when we move past the usual mill and grower concerns about sharing the returns for sugar, ethanol, molasses and cogeneration.

There did seem to be a consensus view that it would be premature to revisit the cane payment formula until an actual opportunity arises.
SCALE OF OPPORTUNITIES

How large should a new opportunity be? Some said that it should totally replace sugar production at a mill, and others said anything that makes a profit is worth doing, no matter how small, plus every view in between.

For commodity type products such as biofuels and some basic or commodity chemicals, it was recognised that larger scale is better.

For second generation technologies looking to use bagasse and/or tops and trash, the biomass production of several mills and catchments would likely be needed as feedstock or a biorefinery. The logistics costs of transporting biomass like this would likely be too high for most low margin products.

Larger scale also means more efficient use of invested capital, leading to lower unit costs.

Specialty chemicals and other high margin products typically have smaller markets and can be profitable at a smaller scale.

Another topic of discussion was whether a diversification opportunity should benefit all at the same time. As a challenge question, if there was a diversification opportunity for growers in their fallow year that would only benefit 100 growers, should this be pursued? One view would be that, no, as it does not help all growers. A counter to this is that if we can improve the long-term viability of those 100 growers, then we can move on to the next 100, or 500, and so on.

Some niche markets already exist, for example for Rapadura and Panela sugar - of which, anecdotally, some 5000 t are imported into Australia each year and sold under claimed health benefits for the minerals and vitamins retained compared to refined sugar. Given the high price of such specialty sugars (>10/kg retail price) there is clearly a domestic market, and potentially an export market, however, it is not an industry changing product.

Taking smaller bets was raised by a number of participants for the following reasons:

- You only bet what you can afford to lose (i.e. don't bet the farm on it.)
- When you do, you prove up the process, including capital and operating costs, plus process yields, and can deliver product to customers to develop the market.
- You can match a domestic market need.

CAPITAL COSTS

Capital costs are known to be high in Australia.

Anecdotally, it costs twice as much to build an ethanol plant as in the USA, and three times as much or more to build a new sugar mill than in developing countries. This was heard from several parties.

Longer crush seasons in Brazil and other countries compared to Australia lead to better utilisation factors for their mills. Even if their capital costs were the same as ours, they can spread the fixed costs of their facilities across more days in operation, leading to lower long run marginal costs for sugar production. Our capital costs are higher, and our crush season is shorter, adversely affecting sugar production costs.
The high cost of capital likely makes it difficult to justify the financial investment decision (FID) for new projects for many company Boards. However, external capital is available for projects that can strike suitably long-term supply and offtake agreements, with the caveat that it is hard to achieve offtake agreements for the length of time and price that investors and banks would like.

Australia is seen as a good place to do business as it has a good legal regime and policies. On the other hand, precisely because of that, it can take longer to achieve approvals and meet planning requirements than in other countries.

Also factoring into the discussion was the high probability of cost blow outs for innovative production processes that are scaling up from pilot or demonstration size.

Do all the above adversely affect the development of value add operations in Australia? Yes.

There was a more positive view that even foreign owners consider projects here on their own merits. Equity funds and banks also look at projects on their own merits too in Australia.

Suggested pathways included viewing opportunities in the following manner:

- Look for domestic opportunities which will support the price and volumes of production - for example, the ethanol mandate.
- Build a bigger plant to achieve good economies of scale to bring down the cost of production for every litre or kilogram of product.
- Focus on higher margin, smaller volume markets.
- Combine the previous two points and build a large contract manufacturing biorefinery and have multiple customers producing high margin, smaller volume products.
- Let a third party take the risk and build the plant themselves.

THIRD PARTIES

Many of the most promising innovations in biofuels and biochemicals come with high levels of technical and market risk. These third party technologies haven't been scaled up to commercial size yet, so the cost of construction and operating costs remain untested. Also, the demand for the product is not yet proven. The market for the product could be new or even non-existent yet.

Defining this level of technical and market risk for new technologies opened up wide ranging discussions on how, if, and on what terms third parties would be welcomed on site at mills.

A common view was that third parties often saw the mills as feedstock and utility providers - selling cane juice, bagasse, molasses, steam and electricity, all at a discounted price, to an onsite plant.

Mills would prefer to have some skin in the game, so to speak. An ability to share in the upside.

Other key views included:

- Bagasse costs are problematic for many bioeconomy companies. US Department of Energy work has shown that a biomass cost of US Dollars $30 - 40 per tonne (dry basis) is needed to unlock the global second-generation fuels market and compete with oil as a feedstock. That works out at $40 – 50 Australian dollars per tonne (dry basis). However, given the opportunity cost of converting bagasse into electricity,
bagasse is typically priced over $100 per tonne (bone dry basis). This price mismatch is problematic for the development of second generation technologies.

- The potential failure of third party companies was discussed in the context of the risk of bankruptcy of smaller companies or projects. That is, a bankrupt or low profit biorefinery located next to a sugar mill could end up becoming an encumbrance, taking up land and resources which may have a higher value use with another party.
- Some mill site footprints are simply too tight to co-locate a biorefinery of some sort, either now, or as a constraint to future expansion.
- Larger companies are, in theory, better able to absorb the financial risk of projects; however, they would typically want to build a larger facility, which would likely require the cane juice from an entire mill, or the bagasse from multiple mills. In addition, it is apparently quite normal for larger companies to go ‘jurisdiction shopping’ asking for the maximum government support as an incentive to build here.
- Biorefineries require deep pockets.
- Researchers often underestimate the level of effort and cost to commercialise their inventions.

**There’s no shortage of third parties**

Some survey recipients mentioned that they receive multiple approaches per month, sometimes even more than one per week. The internal resources required to perform even basic technical and commercial due diligence on received proposals is in most cases not available.

A few participants asked if it was possible for SRA to help with due diligence, even keeping abreast of technologies and third party proponents on behalf of the sugar industry. This may be possible under the recent changes to the SRA constitution allowing for consulting, however, not all participants were in favour of this approach. Some questioned the ability of SRA to provide reasonable and timely commercial and technical due diligence.

The ability of SRA to compete with third party R&D was also raised as a topic. Given the 900 or so companies trying to commercialise their bio industrial technologies28, plus large companies spending many millions of dollars on R&D, it was asked how SRA could even begin to compete with that level of investment given its small budget.

**Industry approach to third party innovation**

Discussion of the boundaries of the sugar industry’s skillset and capital to take on the risks of innovative projects highlighted that perhaps the focus of industry is on projects within their own control (e.g. value added sugar as a food product, ethanol and power generation).

Picking interesting innovations and then going on the journey of commercialisation seems nowadays not to be the preferred path for sugar industry participants. Requiring third parties to take most, if not all, of the financial and technical risks of process development seems to be the dominant view.

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However, instead of seeking participation in the commercialisation journey, the majority preference was for the ability to retain control such as through licensing a technology and building a plant – a so called turnkey technology solution.

The exceptions to this view were where smaller bets were possible. For example, if a process could be proved up at a small scale for a few million dollars with product being marketed and sold to prove the business model, then this could be of interest. It was noted that this approach is more common in other countries than here, plus some prefer technologies that could be scaled to convert an entire mill's output from sugar to the new product.

**WHAT CAN GROWERS DO ON THEIR OWN?**

During this consultation we asked how growers/farmers could undertake diversification and value add activities on their own.

The caveat to this, agreed by all parties, was that any work undertaken solely for the benefit of growers would lead to no less cane to the mills. This caveat is vital as even a modest reduction in cane harvest could lead to mill closures.

The discussions held with growers on this topic led to a few main topics, being:

- Doing something with tops and trash
- The need for infrastructure for some fallow crops (silos, processing facilities, etc.)
- Reducing costs
- Improving yields, and
- Reducing harvest losses

**INDUSTRY CHANGES**

One of the philosophical questions in value add and diversification is 'what industry are we doing this for? Today's or the one in ten years from now?''

Factors quoted include:

- Further vertical and horizontal integration of growing will occur over the next decade. Vertical integration with millers farming, and horizontal with large corporate growers increasing the size of their operations.
- There are less and less growers, with even less expected in 2030. This will likely be driven by the retirement of smaller growers.
- Most mills are foreign owned. Ownership can change too.

Given that the translation of research into commercial products can take ten or twenty years, it is an interesting question to consider. The main lesson from the question is that there are potential trends in industry that could be considered when setting strategy in value add and diversification.

**INTERNATIONAL COOPERATION**

The common theme when it comes to international cooperation fell into two basic categories.

1. More Innovation is happening overseas more in Australia - a lot of money is being spent outside Australia.
2. SRA's only has a small budget, so it should seek to leverage its investment as best as possible by working with international organisations and universities.

Other comments included:

Given the level of foreign ownership in our sugar industry, it is possible, even likely that innovations will be tried overseas first.

For value add products the competition is both international sugar operations, and other crops (corn, soy, other advantaged biomass, etc.). Given the common ownership of many sugar operations and the need to ensure the sugar industry can grow, cooperating internationally on sugar will be important.

The key advances are coming in those places growing the fastest. For example, they have built 500 mills in Brazil in the last 50 years. Leverage those.

The US Government spends hundreds of millions on all matters agriculture and the bioeconomy. The German government currently has a large budget for the bioeconomy. Let's tap into that.

We are, as a nation, in most ways late adopters of technology, not the leaders. Our market presence is just too small.

Going it alone is not a good idea. Being so small and so poorly funded, we will never leapfrog our international rivals. Trying to get ahead of the curve from our base is a losing proposition. Join them or be left behind.

The rest of the world's sugar industry is envious of the knowledge and capability of SRA. With the change in constitution to allow consulting working internationally will likely become normal. Given the common ownership of the local industry and the international competition, this only makes sense.

The issue is not so much that we should be guarding our secrets from our international competitors, that we should find compelling reasons for them to allow us to share the work which they are majority funding.

The final point above represents an interesting challenge for the industry and SRA

**WHO IS THE COMPETITION?**

Competition was discussed in multiple contexts; sugar, land, other biomass sources and sweeteners as an alternative to sugar.

**SUGAR COMPETITION**

International competition was cited as a concern for industry viability in terms of price.
For many of Australia's sugar industry competitors they sell their product into a local market that pays at, or higher than the international trade price. Also, some countries have a limited number of importers, reducing the size of the possible market.

In Thailand and Brazil, the industry already receives the benefits of value add and diversification through ethanol, alcohol for consumption and cogeneration. They also have some diversification opportunities, such as paper and board products, which rely on lower labour costs.

Other competing countries also have lower labour and capital costs than Australia.

However, our main markets in East Asia view Australian agriculture as being 'clean' or 'natural', which could be a point of competitive advantage in the market. The Bonsucro Production Standard is an example of the market looking for environmental and sustainable outcomes.

Whether or not the market is willing to pay a premium for such sugar is a separate matter.

**LAND COMPETITION**

Is growing cane the best and highest use of good agricultural land?

In the north it would appear to be, however, near Maryborough and Bundaberg it is increasingly proving not to be the case.

Loss of land under cane is potentially the biggest threat to mill viability.

**COMPETITION FROM OTHER BIOMASS SOURCES**

Forestry waste is a direct, potentially lower cost competitor to bagasse and cane trash in the densified biomass export market.

As a source of biomass for second generation technologies, the US has been focused on low cost biomass crops at a price of US$30 - 40 per dry tonne ($40 – 53 per dry tonne in Australian dollars using a 0.75 USD/AUD exchange rate), which is anecdotally lower than our bagasse prices which range from $100 -150 per dry tonne.

South East Asia produces a lot of forestry waste, agricultural residues/wastes including palm oil empty fruit bunches (EFB), coconut shells, and other.

Corn remains the most advantaged crop as not only is the cost of fermenting ethanol from corn known to be lower than that from molasses, but the stover, cob and a distiller’s grain can also be produced, increasing revenues and potentially lowering the cost of biomass.

It was noted by a few parties that our relatively short crush season leads to higher unit costs of production due to lower asset utilisation. Growing supplementary crops for the non-crush such as agave in dry lands, sweet sorghum and energy canes for use in the lower yielding shoulders of the crush and in the non-crush may help improve asset utilisation and provide more biomass at a lower unit cost.

**COMPETITION FROM SWEETENERS**

With the current trend of reducing sugar intake in the developed world, low calorie sweeteners are likely to be a growing competitor to sugar.
However, sugar could still compete in this space. For example, fructo-oligosaccharide (FOS) is a known sweetener which can be made from sugar. Also, Amyris, the US company, is making a sweetener using its intellectual property on fermentation of sugar.

THE ADVANTAGE OF SUGAR

Sugar is a great foundation for use in biochemicals of all sorts, and this was well recognised as a potential priority for industry.

Some non-industry parties mentioned the possibility of maintaining our sugar industry not as part of the food chain, but as part of a future biochemical future. Some industry parties have a similar view and proposed sugar based biochemicals, rather than lignocellulosic biomass based biochemicals as their preferred pathway.

NEW MILLS

Expanding the sugar industry was discussed as it is possible that moving west and north may reduce social license to operate issues related to the Great Barrier Reef, and by setting up with broadacre cane production, cane production costs could be lowered. It could also allow for a new, more efficient mill to be built.

Discussions on this raised the following:

- Almost all options will require the building of new dams and irrigation schemes, none of which are likely to pass through approvals for 5 to 10 years. The average time for a new dam to be approved is 7 years.
- If you did build a new mill, you might be better off building it in a location with existing cane supply, rather than bearing the full costs of establishing cane farms with roads, utilities, transport infrastructure, etc.
- The capital costs are two to four times as high here as overseas.
- It would mean introducing higher logistics/transport costs to get to port and given that it might only incrementally improve sugar production costs, would it be economic regardless.
- A few mentioned that if scales of 40 to 60 thousand hectares or land under cane could be achieved, then a new mill could be possible.
- Starting again could make sense for some. Existing mill sites are often constrained in terms of land size and layout. Like the housing industry there is always a point where it is cheaper to build a new house than to modify an existing one.
- Capital constraints are one reason new mills are not being built. For example, anecdotally, banks are not keen on sugar mills due to the volatility of sugar pricing. Companies with large balance sheets could finance a new mill themselves.
- Introduction of new mills as a way of introducing competition for cane was mentioned, with reference made to the proposed NQBE project at Ingham. Reference was also made to Chinese growers selling their cane to whichever mill offers the best price on the day.
- Establishing new areas of land under cane, under corporate control was raised as important for ethanol and biochemical production, as is demonstrated by the proposed RDA Pentland ethanol project. For such plant, maintaining viability by having consistent feedstock costs is more important than achieving best prices for sugar sales, and by not producing sugar, there is no opportunity cost for not selling sugar.
LOGISTICS

Logistics costs are key to all efforts in value add and diversification.

Australia remains somewhat competitive with Brazil as its mills are closer to port. The free on board cost (FOB) for sugar in Brazil reflects both the lower sugar production costs and the materially higher transport costs to get to port. Our FOB cost is not materially higher than that in Brazil.

Raw sugar is exported via the bulk load sugar terminals as if the product were further refined it would need to be shipped in bags or containers at a much higher price.

Given that logistics is key to raw sugar sales, it should be of no surprise that is a key determinant in the viability of value add and diversification activities.

For example, Queensland only has two container ports, Townsville and Brisbane, with Brisbane having the greater volume. Most high value product types require transport in shipping containers or ISOtainers for liquids. The high costs per tonne of sending containers by rail or truck to Brisbane need to be factored into any project economics. For some processes, process input materials may need to be imported by container, e.g. from Singapore, and transported up to the process plant. This too can be expensive.

Some low value bulk goods such as animal feed may only be economic within a short driving range of the place of production. E.g. a 300 km maximum distance is typical as it allows a truck to load, travel to destination, unload and then make the return trip in a single day.

Queensland does, however, have good port access for bulk dry commodities and bulk liquids. It was for this reason that participants were asked about densified biomass and ethanol production as the logistics costs for these could be acceptable using existing nearby port facilities.

Access to the electricity transmission and distribution grids is a form of logistics too. Cogeneration is a valuable potential diversification pathway. However, the main loads are in South East Queensland, and the losses in the system are quite high. For example, in the Cairns region some renewable generators are only getting paid for 85% of their production as the marginal loss factors (MLF’s) for getting electrons from Cairns to Brisbane are high. Additionally, the grid is becoming constrained as more solar PV and wind farms come on line, and there may be difficulties or curtailments in dispatch during daylight hours in the coming years.

GOVERNMENT POLICY

Government policy was a popular topic. Matters raised include:

- Conflicts in policy purpose. For example, with regard to the Queensland State Government, Biofuels and Biofutures Queensland initiatives are well as good, however, policy and regulations on vegetation management and the Great Barrier Reef act against the industry growth and management.
- Sovereign risk - the changing of laws- is seen as a risk to investment. For investors, even just the perception of sovereign risk is damaging. The Competition and Consumer (Industry Code - Sugar) Regulations 2017 were quoted by some parties as an example of sovereign risk, though we clearly understand this view is not shared by all.
• Regulatory uncertainty is also seen as a barrier to investment. For example, uncertainties surrounding the Commonwealth Renewable Energy Target levels and prices may have had a factor in the relatively low adoption of cogeneration in industry.
• There was recognition that Government has helped in times of need, and that a positive relationship with Government would help with value add and diversification.

HARVEST LOSSES/MILL GAINS

Harvest issues were the single most discussed matter of the consultation process - even though it was not a formal value add and diversification topic.

There were many views, including:

1. Too much cane juice is lost in the field due to blunt blades, short billets, etc.
2. Some losses will be inevitable. Speed and quantity are important too. Somewhere in there is an optimum balance.
3. We need 2 and 3 row harvesters here that don’t overly compact the soil.
4. It will be the Brazilian market that drives the production of 3 row harvesters that don't compact the soil too far.
5. Harvesters are the same basic design as per the original invention here 75 years ago. Where is the new technology?
6. When are we going to move to 24/7 harvesting and reduce the amount of capital tied up in assets?
7. We know how to harvest better, it's been proven time and time again.
8. Can we put this to bed once and for all? Prove that best practice in harvesting helps the mills too, or not.
9. Equity is the reason we harvest in the pattern we do. Yes, it might more efficient use of capital to move to a clock-face harvest system, however, there are good reasons for the current system.
10. We need to consider harvesting to keep cane trash too as that can be a valuable product itself.
11. Can harvesters be electrified? Could the generate electricity from sugar derived ethanol going into on-board fuel cells.

FARM SYSTEMS/BMP UPTAKE

The adoption of best practices in farming was a widely mentioned topic.

"There are so many things we know how to do better. Why aren't we doing these things?"

We have the most productive growers in the world, but they only account for 20-30% of growers. How do we get the others to adopt best practice?

Cane Changers is a good example of how to drive adoption.

Where is the internet of things, sensors, AI and autonomous equipment in all of this?
Some of the biggest improvements to yield require spending money, which for many is out of reach or won't achieve the returns they need.

The information is all there, for free, from SRA. We don't need anyone to help us.

Farmers in other sectors regularly use agronomists who themselves use publications from their sector's equivalent to SRA.

There is a low level of transfer of skills, especially to the smaller growers.

Many growers make ends meet through second jobs, and for some cane is their second job. This means less hours going into maintaining their cane. How can we help these growers?

Adoption/extension of farming practices are not part of value add and diversification. However, they are related in the sense that if the industry can improve tonne per Hectare yields through farming practices, then that benefits growers and the millers with better revenues.

**AVAILABILITY OF REPORTS/INFORMATION**

Even with the SRA eLibrary readily available, access to information is seen as a potential barrier to innovation, including value add and diversification.

Attitudes, wrongly or rightly, included:

- Questions on the availability of reports from BSES, SRDC and the former CRC Sugarcane Based Biotechnology. The thinking here is that there is little new in industry, and if you are looking for information it probably already exists in one manner or another.
- For multi-year studies, the availability of results through access to milestone reports was raised. Industry would like to adopt changes if they are shown to work prior to the publication of the final report.
- The approach and communication style used by researchers may not translate well for growers and millers looking to adopt the results of that research.

There was some commentary that foreign companies could use this information to their advantage over Australia. The counter views were:

- They already access this information through local companies.
- Australia stopped leading innovation twenty years ago. They are the leaders now.
- It represents a large pool of intellectual property that could provide the foundation for SRA to provide fee for service and consulting to other countries. Could SRA charge for access to foreign organisations or institutions?

Without picking sides in the above arguments, what is clear is that there is a lot of knowledge held at SRA, and that there are questions as to how best access that.

**GOING DIGITAL**

Better use of data across the supply chain was recognised as a topic of interest.

Use of such data could improve efficiency and lower costs for industry.
The key question is how data could be used to make decisions.

Remote sensing, drone imaging, autonomous harvesters, soil condition sensors, GPS, alternatives to BRICS, harvest optimisation for mills and growers, the internet of things (IoT), 5G networks, machine learning, industrial mathematics for optimisation, etc. are all potential areas for further work.

There was a sentiment that working with data is not a current strength for SRA, both as a discipline and in its people.

It was also noted that there are practical difficulties in negotiating data license agreements for SRA and organisations providing the data. The ownership of the data, and protecting proprietary information are the key issues.

A realistic vision for the future of the sugar industry using digital advances was cited as something needed to advance this topic.
4. Value add and diversification – industry views

At the commencement of this study it was assumed that there were specific products or chemicals that industry would choose as a priority. Instead, the discussions held with industry participants were wide ranging and quite broad, with much of the emphasis on helping resolve uncertainties, and on a few key topics.

The following notes are the key points from those topics that industry participants discussed.

MARKET WATCH

The SRA 2017 - 2021 Strategic Plan mentions the option for a market watch service, and this potential service was rated most consistently by those consulted.

Given that the main barrier to value add and diversification was greater certainty on the market (prices and volumes), it is unsurprising that this was a common ask. It is also a service that could fit well within the budget available to SRA for value add and diversification.

The main issues for SRA to consider are:

- What products and commodities should be included? E.g. Ethanol, plastics, animal protein, densified biomass etc. Do new or speculative products get included too?
- How often should updates be provided?
- What level of analysis or commentary would be most useful? E.g. Spot price quotes, industry trends, longer term forecasts.
- Is there a green/renewable premium for bio-derived products (e.g. bioplastics), and how could this be quantified?
- How can SRA leverage existing research from investment banks, data brokers and other parties?
- How can SRA provide a consistent service given that this is not an offering that would appear to be part of the cultural DNA of the organisation to date? For example, if external providers are used, then how can continuity and consistency of the offering be ensured.
TECHNOLOGY WATCH

When it comes to new technologies and products, it is hard to keep up with progress. Consequently, there is a desire to have a technology watching brief. Issues for consideration include:

SRI used to provide a technology watch service. It was considered useful, and mills would use that information when replacing equipment at the end of life cycle and incorporated new techniques into operations.

The aim is to help industry be informed buyers and tapping into what is happening overseas is important.

For example, there are some 900 companies listed on the Biofuels Digest database, attempting to commercialise biofuel and biochemical technologies. When a company a week is coming in and seeking to partner or ask for investment, it would be good to know the general state of technology and how that company might fit.

When asked if SRA had a role in due diligence on companies and opportunities the majority said it wasn’t a role for SRA, but that providing the technology watch service could aid.

A watching brief could pick a number of topics or technology pathways rather than look at everything.

Knowing what is happening in universities and other research institutes would also be valuable.

It was suggested that SRA researchers could use their existing networks to find out what is happening locally and internationally.

SUGAR AS A FOOD PRODUCT

The sugar industry is a food industry

We are disconnected from the end market. If we know what they want, we can innovate better.

The current trend against sugar for health reasons was raised, as was the desire by customers to the same taste outcomes, but with lower calories. This could be through low GI sugar, blends of sweeteners and sugars, somehow retaining the bulking properties of sugar in recipes.

It was noted that there are also opportunities to identify components or molecules in sugar that could be used to make flavourings or other food industry products.

In terms of value add opportunities a few raised the idea of combining sugar products or by-products with products from other industries rather than looking solely at sugar as a sweetener.

29 DigestData - The advanced bioeconomy's premier project and organizational data portal - relational, granular, global, messaging-enabled, http://biofuelsdigest.com/digestdata/
COGENERATION

Mills were designed to dispose of bagasse via burning it in boilers. It makes sense, therefore, to take the next step and upgrade the boilers, electrify the mill drivetrains and send out electrons. However, experience with cogeneration has been mixed.

Market risk has been cited as problematic and was an issue for plants built prior to 2010. Regulatory uncertainty regarding the Australian Government Renewable Energy Target (RET) as a means of underpinning any cogeneration investment has also been cited.

On the other hand, it provides an alternate revenue stream to mills.

ADDITIONAL INFORMATION

One of the key issues is the level of uncertainty of electricity generation and demand in the future. This is affecting the whole of the electricity industry, not just potential cogeneration projects.

The increased installation of solar, which generates in the daytime may adversely affect new build cogeneration plant economics if they must turn down during the day due to the lack of available transmission capacity available after solar energy is dispatched. However, there is an increased demand for afternoon peak generation, especially from green sources such as bagasse. There is also a potential market for system support - i.e. reliability.

Figure 7 – Illustrative daily demand in Queensland, based on a typical Summer’s day (January 2018)

There is recognition by corporate buyers that action needs to be taken to do the right thing and reduce carbon emissions in their supply chain. Consequently, corporate power purchase agreements (PPA’s) have underwritten renewable projects above and beyond the Commonwealth Renewable Energy Target.

Due to the rapid increase in utility scale generation, in the near term there will likely be constraints on the electricity grid during daylight hours. There are several recently announced projects to ‘time shift’ the solar generation to more valuable times of the day through the use battery storage and pumped hydropower projects in which water is pumped from a lower reservoir to a higher one using cheap electricity, and during higher price periods water flows back down, generating electricity.

In terms of demand, there is a growing consensus that for the near-term roof top solar PV generation will decrease the amount of electricity required from the grid, which in turn is increasing network operating charges as the same asset base is used to deliver fewer electrons. However, once electric cars achieve greater uptake, the demand for electricity is
expected to increase materially. Simplistically, the grid and electricity market are currently set up to provide for those industrial and residential activities that use electricity, including the big increase in demand that occurred in the late 90’s when there was a major increase in air conditioner installations.

The increased uptake of electric vehicles mean that users are switching from petrol and diesel to electricity. This is forecast to require big changes to demand as the effect of recharging cars in the evening will likely create a bigger increase in demand than the introduction of air conditioners.

This change could create opportunities for existing and new cogeneration to counterbalance the adverse effect of increasing solar generation during daylight hours.

Some people thought there could be a role for setting up, or utilising an existing electricity trading service, potentially combining several cogeneration facilities in order to achieve the highest revenues for the sugar industry. For example, coordinating the outputs of several mills to provide power purchase agreements could be valued by buyers. Also suggested was combining the build of a new plant with the development of solar PV so that the two projects could coordinate and provide a 24/7 supply of electricity from renewable sources, which could also be valued by buyers.

The industry seems to be looking at how the MSF Tablelands Cogeneration Plant will succeed. Also, the ability of the proposed North Queensland Bio-Energy (NQBE) project to sell its power will be a test for the viability of new projects facing competition from solar PV.

In terms of roles for SRA, looking at energy canes to increase the bagasse (fibre) available for cogeneration was considered the main option. Additionally, the use of Agave or Sweet Sorghum as a source of fibre for use in the non-crush was raised for consideration.

**INDUSTRIAL ETHANOL**

The rules of thumb for ethanol production are:

- 2 tonnes of sugar to make 1000 litres of ethanol
- 4 tonnes of molasses to make 1000 litres of ethanol

Current production at the Sarina mill is from molasses, Australia’s only industrial ethanol plant linked to the sugar industry.

With current low oil prices, the main driver for domestic usage are ethanol mandates by government.

There is a large export market, however, the cost of shipping the product is high, and buyers tend to lock in purchase contracts for only the short-term (a few years only) as there is growing competition in the market. This short-term contract approach makes it difficult to obtain project financing for new projects in Australia, with the banks seeking long term contracts.

**CURRENT PRODUCTION IN AUSTRALIA BY PLANT CAPACITY**

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30 Personal communication with Troy Philpot – VP Business Development, Yurika (the consulting arm of Energy Queensland) November 2018.

1. Manildra Ethanol Plant, NSW, 300 million litres per annum - made from waste starch.
2. Dalby Biorefineries, QLD, 80 million litres per annum - made from grain
3. Sarina Distilleries, QLD, 60 million litres per annum - molasses

There are multiple proposed projects with none currently known to have achieved Financial Investment Decision.

**CURRENT MANDATE LEVELS**

1. NSW - 6% of petrol sales as E10.
2. QLD - 4% of petrol sales (4% of sales must be E10)\(^{32}\).
   a. In 2018, some 605 million litres of E10 was sold, equivalent to 60.5 million litres of ethanol. When the E85 sales are added in, only 2.8% of petrol sales were ethanol in 2018.
   b. An approximate conversion rate is 21 million litres of ethanol per % mandate. Consequently, to establish a new ethanol refinery of the order of the size of Sarina would require a mandate of 6% or so in Queensland.
   c. New entrants are asking for a mandate increase to underwrite the capacity of new plants.
3. VIC - voluntary - E10 and E85 are available for sale at some retailers. Should a mandate be introduced in Victoria, it should stimulate the development of domestic ethanol production.

E10 petrol is a RON 94 product, and it contains 3% less energy than RON 91. E85 petrol is a RON 105 product\(^{33}\).

**INTERNATIONAL MANDATES**\(^{34}\)

1. Brazil - has a mandate of 27%, however, this has historically been reduced to as low as 20% when supply was low
2. US - has recently allowed the sale of E15 all year round. E15 is considered safe to use in automobiles made in 2001 or later. Most petrol sold in the US is E10.
   a. Refiners prove compliance with biofuels blending requirements through the acquisition of and acquittal of instruments known as Renewable Identification Numbers (RINs).
   b. US ethanol producers also receive some tax credits to promote domestic production over imports.
   c. California has a Low Carbon Fuel Standard (LCFS) which provides higher prices for low carbon fuels. California’s aim is to reduce carbon intensity in the whole life cycle of the fuels, including agriculture and land use.
3. China has expanded its role out of E10 to 15 provinces, coming into effect in 2020. When fully in effect, this mandate will see demand increase from 2.6 million tonnes to 12 million tonnes. It is thought that much of the feedstock for this increase will come from spoiled grains and corn in China. From 2025 there is a target of switching to renewable fuels (that is, drop in fuels likely made from biomass), however, like the USA, this will depend on the development of commercially viable second-generation fuel technologies.


\(^{33}\) A history of ethanol blended petrol in NSW: https://www.e10fuelforthought.nsw.gov.au/history

\(^{34}\) Biofuels mandates around the world, 2019; https://www.biofuelsdigest.com/bdigest/2019/01/01/biofuels-mandates-around-the-world-2019/
4. The Philippines has an E10 mandate, however, this is considered to be at risk to political decisions.

**CANE JUICE**

The economics of ethanol production from cane juice were discussed by a number of participants, particularly the issue of having a mill capable of swinging between sugar and ethanol production.

Diverting cane juice from the sugar production processes to ethanol production processes can potentially adversely affect the costs of sugar production. Namely, the same fixed costs exist for sugar production equipment at the mill, however, if less cane is sent to sugar production, then the fixed costs are spread across a lower production. Likewise, you would normally run an ethanol plant at its highest utilisation rates to keep production costs low.

It was noted that some plants in Brazil had escaped this in the past due to lower capital costs for construction, and also lower labour costs, however, this is thought to be changing.

Questions for SRA included:

- Could SRA help look at how the crush season could be extended to produce more ethanol? This would cover varietals, harvesting, yields, economics, etc.
- Could SRA assist with non-crush season crops such as Sweet Sorghum and Agave to allow for ethanol production, and mill utilisation in the non-crush.

**DENSIFIED BIOMASS**

Densified biomass can be made from bagasse or tops and trash.

In general terms, the biomass is treated to remove alkaline (e.g. Potassium) and chlorine components, then it is densified and dried. Products can be in the form of pellets, extrusions or other.

The energy content of the final product can be as high as coal on a per tonne basis but has a lower density than coal, so it takes up a greater volume than an equivalent amount of coal in logistics.

Bagasse ex-mill was processed using steam and has most of the unwanted potassium content removed.

Tops and trash need treatment to remove the alkaline elements such as potassium and chlorine, and it would likely need to be collected at harvest as a contamination with soil when collected from the trash blanket would likely not be acceptable for end users.

The end uses include coal replacement in electricity generation, cement clinker production and in steel making.

The market driver for electricity generation is State owned generation assets across the Asia Pacific, as well as Australia, looking to reduce their greenhouse gas emissions through inclusion of biomass in the boilers as a percentage of feedstock. This was first attempted by the industry in the early 2000’s, however, initial efforts were based on taking green waste directly, and lessons were learned about the need to treat the biomass first. The delay in uptake of densified biomass to date has been attributed to the cost of treatment, pelletisation, dehydration and other processes as needed.
The steel making industry is also potentially interested in a renewable alternative to coal as a percentage of their feedstock. The sunk costs of the steel furnaces are high, so steel makers are looking to reduce their greenhouse gas emissions which currently account for 5-7% of global CO2 emissions.

In terms of logistics densified biomass is attractive in the sense that it is a bulk product that can use the existing sugar terminal facilities, or even coal terminals. Queensland has two ports that load containers, Brisbane and Townsville. So, any products that can use other existing port infrastructure could be of interest.

Other points mentioned include:

- Altus Renewables is already exporting densified wood pellets via the Bundaberg Sugar Terminal.
- There are several projects already looking at densified bagasse and tops and trash.
- There could be potential work for SRA in technologies associated with treatment, pelletisation/extrusion and dehydration - the key would be in reducing capital and operating costs.
- Additional biomass could be made available using energy cane, sweet sorghum or other crops. Also, potentially of interest could be blends of sugarcane derived product with other crops, e.g. wood.

CHEMICALS FROM SUGAR

Chemicals from sugar were overwhelmingly supported over pursuing chemicals from biomass. Chemicals can be made from crystal sugar, cane juice, molasses and ethanol produced from both.

Seemingly, this preference is due to the known lower cost pathways for making chemicals from sugar, whereas, typically one must extract sugars from biomass as feedstock first, which is, to date more expensive than taking sugar from cane juice.

The biomass pathway is currently thought to be more expensive, although, it may be preferred in the public's mind as it doesn't use a food product. This trend is already evident in the EU's July 2018 revision to biofuel targets, now favouring second-generation biofuels over time, and phasing out first generation biofuels.

Amyris Inc., and its processes for creating valuable molecules from sugar was quoted as an example by several parties. Interestingly, Amyris Inc. started with the aim of making diesel but has shifted to nutraceuticals, cosmetics, vitamins and most recently Cannabidiols (CBD) as high value products.

It was recognised that typically one needs to have deep pockets to enter the specialty chemicals industry, and the potential role of SRA was questioned from the viewpoint that it has a limited budget and that not all organisations would pursue the same chemicals at the same time.

CHEMICALS FROM BIOMASS (SECOND GENERATION)

There have been several demonstration and commercial scale cellulosic ethanol plants, however, due to several factors, including oil prices, lower than expected process yields, and higher than expected costs, they have, so far, failed to prove commercial.
Typically, processes extract cellulose and hemi-cellulose sugar from the fibre of the plant, with the key challenge being economic, low cost pre-treatment technology.

The list of chemicals that can be made is well known, with the US Department of Energy\textsuperscript{35,36}, and the International Energy Agency\textsuperscript{37} both publishing lists of the most promising.

The price of bagasse is also a challenge for the biomass to chemicals pathway, primarily due to the high opportunity cost offered through burning it to make electricity.

It is likely that a consumer and regulatory led approach, requiring biochemicals from second generation sources, will be required to create broad demand for these products. Many startups were established on the back of regulatory targets for so-called drop in fuels (aka advanced renewable fuels), however, they seem to have recognised the difficulties in competing with fossil fuels and are now looking at performance-advantaged biobased chemicals\textsuperscript{38}.

Pathways that create several products/by-products are likely to be more economic than single product processes. For example, Mercurius's REACH™ process produces valuable by-products, and as a platform chemical, can be used to create a portfolio of products, which could be quite valuable in the market.

Leaf Resources, the Brisbane based company which aims to be a world leader in cost-effectively producing high purity sugars from lignocellulose, is currently building its first plant to in Malaysia, based on palm oil empty fruit bunches (EFB). The high costs of bagasse are cited as a reason for not building their first plant in Queensland, though, they are completing studies on building their second plant here.

In past decades, efforts were focused on making ethanol from biomass as cheaply as possible, and then processing that further into chemicals. Much of the effort went into pre-treatment processes and technologies to most cost effectively extract the cellulose from lignin.

More recently, there has been a focus on producing so called platform molecules, such as HMF and more recently CMF. These molecules can be converted readily into other chemicals for use in the chemical industry supply chain.

It was widely thought that SRA probably doesn't have a strong role in second generation chemicals, primarily due to the high cost of development of processes. However, development of energy canes to provide higher fibre could be an area of focus should second generation technologies improve.

\textsuperscript{35}Top Value Add Chemicals From Biomass; Top Value Added Chemicals from Biomass Volume I—Results of Screening for Potential Candidates from Sugars and Synthesis Gas, 2004, US DOE NREL, \url{https://www.nrel.gov/docs/fy04osti/35523.pdf}

\textsuperscript{36}Top Value added Chemicals from Biomass; Volume II—Results of Screening for Potential Candidates from Biorefinery Lignin, 2007, US DOE Pacific Northwest Laboratory, \url{https://www1.eere.energy.gov/bioenergy/pdfs/pnnl-16983.pdf}


RUM AND OTHER SPIRITS

Rum production - we could have funded it ourselves.

Bundy has the market tied up, then Beenleigh.

We looked at it back in the 1980's and missed a good opportunity. It is a single mill and smaller volume businesses - niche market.

Tie up with a major beverage company with existing demand.

Get into the market and with good advertising there is place for another rum producer.

In the US alone, some 3076 million litres of distilled spirits\(^{39}\) (50% ethanol basis) was bottled in 2017. Just over half of this was exported with the rest sold domestically. The US also imported some 160 million litres of rum (50% ethanol basis).

Anecdotally, Brazil dedicates approximately 36 million tonnes of cane per year to the production of Rum (from molasses) and Cachaca or agricole rum (from cane juice) - making some 1500 million litres of Cachaça per year (ranging from 38% to 48% alcohol)\(^{40}\).

Over the last century, Beenleigh Rum and Bundaberg Rum have been the main two producers of rum in Australia. The main players in industry now are:

1.Beenleigh Rum - established in 1884 - is owned by Vok Beverages - a subsidiary of Bickford's Australia.
2.Bundaberg Distilling Company - established in 1888 - is owned by Diageo (the world's second largest distiller). Most bottling operations were moved to Sydney in 2014.
3.Husk Distillers on the Tweed are making an agricole rum and a gin from cane juice. Established in 2012 - their motto is 'Paddock to Bottle'

Globally, alcoholic beverage exports are worth over US$100 billion, with just over 40% of this from liquor.

The following are the top 15 companies\(^{41}\) by sales in December 2018.

1. Anheuser-Busch InBev - Belgium)
2. Heinekin Holdings (Netherlands)
3. Asahi Group Holdings (Japan)
4. Kirin Holdings (Japan)
5. Diageo (UK)
6. Suntory Holdings (Japan)
7. Molson Coors Brewing (USA)
8. Pernod Ricard (France)
9. Carlsberg (Denmark)
10. Kweichow Moutai (P.R. China)


11. Constellation Brands (USA)
12. Thai Beverage (Thailand)
13. Wuliangye Yibin (P.R. China)
14. Brown-Forman (USA)
15. Jiangsu Yanghe Brewery (P.R. China)

If there were interest in alcohol production for consumption, then perhaps there are opportunities for SRA to look at what properties of varietals are best suited to fermentation, and potentially, for the flavour profile of the end product.

For neutral spirits, having undergone multiple distillation steps, flavour is of less importance than the lowest cost of production.

**ENERGY CANE**

While not a new topic, energy cane garnered interest due to new potential markets.

The benefits of having a higher fibre cane is for use in cogeneration, densified biomass production, second generation biochemical/biofuel processes, gasification to make syngas or protein, and other products requiring fibre.

The common sentiment was that when there is a sufficiently valuable market then higher fibre varieties can be produced.

Previous work showed there was a value trade off in losses due to lower sugar quality and the value generated from burning to make electricity. Given the change in markets and end uses, this question could be revisited.

How the cane payment formula would address higher fibre cane was raised by a few parties, not for resolution now, but as a potential future hurdle.
SWEET SORGHUM

The miller sentiment was, almost exclusively, if there was a way to make money out of sweet sorghum, the mills would do it.

The key issues raised, based on prior experience were:

1. Sugar content.
2. Narrow harvest windows.
3. What are the sugars it produces? E.g. Higher fructose and polycose, less sucrose.
4. What would the different sugars mean in the milling process? E.g. would more end up as molasses for less sucrose.
5. Milling characteristics were a problem when trialled before - one varietal just turned to mush/gel.
6. By-products or co-products? E.g. wax.
7. The agronomics are poorly understood compared to sugar cane.
8. Lower bulk density of sweet sorghum billets, adversely affecting logistics and associated costs.
9. SRA will likely have to cooperate with the Commonwealth Rural Industries & Research Development Corporation (RIRDC, trading as AgriFutures Australia), the historical funder of sweet sorghum research, and the Grain Research Development Corporation (GRDC) as they collect the levy for grain crops such as sorghum.

Dr Mark Harrison from QUT has written a brief update on sweet sorghum, as follows. Mark is involved with a few sweet sorghum varietal trials in Queensland and observes that sugar contents and shearing properties are better and can be selected based on varietal.

More information on the potential can be found in:

- The Agrifutures website\(^{42}\) and their 2013 report ‘Developing a new renewable fuel and food industry in Australia: Sweet sorghum.’
- University of Queensland – Centre for Crop Science\(^{44,45,46}\) and the School of Agriculture and Food Sciences\(^{47}\).

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\(^{47}\) Unravelling the sorghum rhizosphere, [https://agriculture.uq.edu.au/project/unravelling-sorghum-rhizosphere](https://agriculture.uq.edu.au/project/unravelling-sorghum-rhizosphere)
Sweet sorghum

Dr Mark Harrison – Senior Research Fellow, Centre for Tropical Crops and Biocommodities, Queensland University of Technology.

Introduction

Sweet sorghum is a rapidly-maturing, C₄, monocotyledonous plant from the family Poaceae. The Poaceae are the most economically-important plant family and includes rice, maize (corn), wheat, and sugarcane. Sweet sorghum produces a stalk up to six metres tall containing high concentrations of fermentable sugars and a large panicle of grain like that of grain sorghum. The sweet sorghum plant has three basic components which can be harvested and used to produce valuable products: grain, juice from the stalk, and fibre from the stalk and leaves. Unlike many other agro-industrial crops, sweet sorghum can simultaneously produce energy, food, and feed products. Sweet sorghum has a wide potential cropping area in Australia including tropical and sub-tropical Queensland, Northern Territory, and Western Australia, and the temperate regions of New South Wales, Victoria, and Western Australia. The integration of sweet sorghum production and milling into the sugarcane industry in Queensland and northern New South Wales offers significant commercial opportunities.

What are the potential benefits of growing sweet sorghum for the Australian sugarcane industry?

The farming of sweet sorghum and processing of harvested sweet sorghum billets in existing sugar mills could have provide several benefits to the Australian sugarcane industry.

1. **Sweet sorghum can be grown on land that is unsuitable for production of sugarcane but within an effective transport radius of the sugar mill.** Compared to sugarcane, sweet sorghum has a higher tolerance to salt and drought (Almodares and Hadi 2009; Smith and Buxton 1993; Gnansounou, Dauriat and Wyman 2005; Nan and Ma 1989; Sutherland 2002; Rooney et al. 2007) while producing greater amounts of biomass (Wu et al. 2010; Türk, Uzun and Türk 1997; Mamma et al. 1996; Mamma et al. 1995; Rooney et al. 2007). Drought tolerance characteristics of sweet sorghum derive from the heavy wax layer and small stomata on its leaves, and an extensive root structure. Reports of water usage for optimal growth vary significantly but suggest that sweet sorghum requires between 30% less water than sugarcane (Sutherland 2002) and 67% less water than sugarcane (Almodares and Hadi 2009) for comparable yields. Smith and Buxton (1993) concluded that sweet sorghum produces more biomass in temperate climates when irrigated; biomass yield was ~90 t/ha for the irrigated crop and ~65 t/ha for the non-irrigated crop. It has been reported that nitrogen fertilisation has little discernible effect on sugar production and total biomass yield from sweet sorghum (Smith and Buxton 1993). This finding was contradicted by other studies that reported improvements in sucrose content and biomass yield with nitrogen fertilisation (Almodares et al. 2008; Rooney et al. 2007) up to 140 kg N/ha (Rooney et al. 2007). This apparent contradiction between the effects of nitrogen fertiliser addition on yield may have been the result of varying residual nitrogen levels in the soils at the sites where the work was undertaken. Collectively, the traits described above offer the opportunity to grow sweet sorghum in existing sugarcane districts on land that is not suitable to produce sugarcane because of the quality of the soil, the quality of available irrigation water, or annual rainfall.

2. **Sweet sorghum production can be rapidly scaled to match predicted/prevailing weather conditions.** In contrast to sugarcane, sweet sorghum can be planted from stored seed with
precise inter-plant spacing using commercially available equipment. As with any seed crop, the ability to control inter-plant spacing is a key tool in optimising sweet sorghum productivity. Precision delivery of moisture and fertiliser immediately adjacent to each seed is viable using fertiliser injector/furrow fertilisation technology. Emergence from the soil typically occurs 3–10 days after planting and effective germination requires soil temperatures of >16 °C and good soil moisture. The yield potential of the plant is set during the vegetative stage, however dry matter production occurs at a constant rate from Stage 2 through to plant maturity (NSW Department of Primary Industries 2005). Following anthesis, the seed develops through a soft dough stage and hard dough stage as the water in the seed is displaced by starch until the plant reaches physiological maturity. The time from sowing to harvest is typically 115–140 days for grain production (NSW DPI 2005) but only 80–100 days for fibre/sugar production; as a result, it is possible to harvest a given area of sweet sorghum twice per annum. The combination of a relatively short sowing to harvest period and seed storage enables sweet sorghum to be planted to exploit existing soil moisture or emerging/predicted weather events.

3. **Processing sweet sorghum requires only minimal modification to milling infrastructure.** There are only a small number of reports describing the processing of sweet sorghum in sugarcane factories. The only reported trial in the last two decades in Australia was by Webster and co-workers (2004). In other countries, two factory processing trials have been reported; Smith, Lime and co-workers, a research team at the US Department of Agriculture in the early 1970s and Woods (Woods 2000) in Zimbabwe. O’Hara and co-workers (2013) undertook sweet sorghum billet milling trials at the QUT Pilot Plant Precinct, Brisbane, to assess the potential impacts of crushing sweet sorghum through conventional sugarcane factory milling trains. Overall, the factory and pilot plant trials showed that no changes to a sugarcane factory shredder is necessary to process sweet sorghum containing stalk only or stalk and leaves. Further, sugarcane factory milling stations will operate at a marginally lower speed with sweet sorghum than with sugarcane for the same fibre rate, but sweet sorghum will likely achieve similar or higher compaction levels to sugarcane.

4. **Sweet sorghum can increase the period over which sugar mill infrastructure is used and increase the amount of crystal sugar produced.** Sweet sorghum is most productive when sown so that vegetative growth occurs during the hottest part of the year. There is the opportunity, therefore, to sow sweet sorghum in tropical and sub-tropical Queensland such that sorghum reaches peak sugar across an extended period outside of the sugarcane crushing season. Sweet sorghum can produce a juice with comparable fermentable sugar content to that of sugarcane juice (Wu et al. 2010; Mamma et al. 1995). Existing commercial sweet sorghum varieties produce juice with higher relative concentrations of glucose and fructose than sugarcane juice, thereby necessitating changes to the process for crystal sugar production.

5. **The amount of fibre available at a sugar mill for electricity production can be increased.** The fibre content in sweet sorghum stalks typically varies from 10–30% and high fibre sweet sorghum varieties are available. It should be noted that varieties with increased fibre content typically contain lower CCS. Given that two sweet sorghum crops can be harvested from the same field each year, growing sweet sorghum provides an opportunity to increase electricity production for export to the power grid without the need to burn coal to supplement the available bagasse supply.
6. The amount of bioethanol (or other fermentation products) produced at a sugar mill can be increased. Sweet sorghum can produce a juice with comparable fermentable sugar content to that of sugarcane juice (Wu et al. 2010; Mamma et al. 1995). Existing commercial sweet sorghum varieties produce juice with higher relative concentrations of glucose and fructose than sugarcane juice, making them particularly suitable for producing juice for direct fermentation but still offering the possibility of crystal sugar production. While there are multiple products that can be produced from fermentation of sweet sorghum juice or sweet sorghum molasses, the product of principle interest in Australia and globally is ethanol for use as a renewable transportation fuel.

What are the main challenges to the integration of sweets sorghum and what is needed to overcome these challenges?

The potential benefits of integrating sweet sorghum production and processing into the existing sugarcane production system are many; however, there are key challenges that need to be overcome before sweets sorghum is a viable option for farmers and millers in the sugarcane growing districts of Queensland and northern New South Wales.

- **Short period of industrial utilisation.** Traditional varieties of sweet sorghum (e.g., Wray, Rio) reach peak sugar in the period immediately prior to grain fill. As a result, peak CCS per hectare may occur across a period of 1–2 weeks. Under such circumstances, crop and harvest management become critical during sugar production from sweets sorghum. Existing pre-commercial varieties have been developed with an extended peak CCS period, but substantial RD&E is required to develop sweet sorghum varieties with a period of industrial utilisation comparable to sugarcane.

- **Low sugar purity.** Traditional varieties of sweet sorghum produce juice with a purity of 60–70%; with a combination of glucose and fructose making up the remainder. Pre-commercial sweet sorghum varieties with sucrose purity comparable to that of sugarcane have been developed but significant RD&E is required to deliver sweet sorghum varieties that produce juice with high sucrose purity and high CCS.

- **A lack of agronomic information.** Sugarcane has been grown in Queensland since 1861 and there is an abundance of information about the agronomic requirements, disease resistance, and performance of existing sugarcane varieties and those emerging from SRA breeding programs in all sugarcane growing districts of Queensland and New South Wales. This information has been accumulated over a century by research organisations such as BSES, SRDC, and SRA, and sugarcane farmers and millers themselves. In contrast, there is a paucity of information about the agronomic requirements, disease resistance, and performance of existing and emerging sweets sorghum varieties. Multi-variety, multi-site sweet sorghum trials on marginal land in sugarcane growing districts are required to address this issue.

- **Lack of information about compatibility with existing harvesting and milling infrastructure.** Existing sugarcane varieties are bred to achieve an acceptable (~15%) fibre content, specific plant architecture, and billet milling properties (as estimated by testing shear strength, impact resistance, and short fibre content during the SRA breeding program). In contrast, breeding of such traits in sweet sorghum is at an early stage. While sweet sorghum varieties with ~15% fibre content are available, (i) the relationship between fibre content, juice purity, and CCS for sweet sorghum has not been determined and (ii) information about the milling properties of the same variety of sweet sorghum grown in different districts is lacking. Further, breeding for sweet sorghum plant architecture (e.g., plant height, stalk thickness, average number of tillers) to maximise compatibility with existing sugarcane harvesters has not been undertaken.
References


FALLOW YEAR CROPS

There seems to be an expectation by observers of the sugar industry that if only fallow crops were done properly then cane growers would be more viable.

The answer from industry was that it was being done, but it is complicated.

Growers (including the mill owners as growers) have experimented with, and continue to experiment with, fallow crops. Where they can make a profit, they do.

The lessons learned include:

- Yields are lower than for cane.
- In some cases, the fallow crop can reduce the yield of the next year's cane crop. For example, rice, and in some places soy, does this by reducing water in the soil. To prevent this some crops are prevented from going to grain.
- The market can be fickle. The domestic price for many crops is variable and is subject to strong competition from dedicated farmers. Some years the price was so low it was cheaper to plough the crop back in than to harvest.
- Where it works well it works well. Each region is different. Examples of fallow crops include soy beans, peanuts, chick peas, watermelon, rock melon, sweet potatoes, pineapple, zucchini, broccoli, garlic, ginger and even cotton.
- Sugar cane is resilient, it can take a flood of up to 3 or 4 days duration and a fire.
- Aloe Vera was trialled, but the market was limited.
- Companion cropping with cane was mentioned.
- There was also mention of some areas looking at 2-year fallow to improve cane yields - which if it were to occur may open up new opportunities beyond annual crops.
- Chemical fallow practices were mentioned, and there may be some work in looking at the effects on soil of chemical fallow and resultant yields.

Overall, the discussion centred not around the fallow crop itself, but the lack of a business model. For example, a soy mill to make soy meal and extract the oil would help value add soy. There were, apparently, silos or storage for soy and other products in the past.

It was suggested that there is a role for government in looking at the infrastructure needs of fallow crop products in terms of storage and processing.

For SRA, there seems to be support for existing services, such as helping determine the effects of fallow crops on further yields.

ADDITIONAL INFORMATION

The Queensland Department of Agriculture and Fisheries (DAF) has identified the following potential complementary annual crops\(^48\).

Table 3 – Complementary annual crops for Queensland

<table>
<thead>
<tr>
<th>Crop</th>
<th>North Coast</th>
<th>Central</th>
<th>South</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peanuts</td>
<td>Not ideal</td>
<td>Suitable</td>
<td>Suitable</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Crop</th>
<th>North Coast</th>
<th>Central</th>
<th>South</th>
</tr>
</thead>
<tbody>
<tr>
<td>Navy bean</td>
<td>Not ideal</td>
<td>Suitable</td>
<td>Not ideal</td>
</tr>
<tr>
<td>Mung bean</td>
<td>Not ideal</td>
<td>Suitable</td>
<td>Not ideal</td>
</tr>
<tr>
<td>Soybean (for grain)</td>
<td>Not ideal</td>
<td>Suitable</td>
<td>Suitable</td>
</tr>
<tr>
<td>Kenaf</td>
<td>Suitable</td>
<td>Suitable</td>
<td>Suitable</td>
</tr>
<tr>
<td>Industrial hemp</td>
<td>Not ideal</td>
<td>Suitable</td>
<td>Suitable</td>
</tr>
<tr>
<td>Pumpkin</td>
<td>Suitable</td>
<td>Suitable</td>
<td>Suitable</td>
</tr>
<tr>
<td>Watermelon</td>
<td>Suitable</td>
<td>Suitable</td>
<td>Suitable</td>
</tr>
<tr>
<td>Rockmelon</td>
<td>Suitable</td>
<td>Suitable</td>
<td>Suitable</td>
</tr>
<tr>
<td>Honeydew</td>
<td>Suitable</td>
<td>Suitable</td>
<td>Suitable</td>
</tr>
<tr>
<td>Zucchini</td>
<td>Suitable</td>
<td>Suitable</td>
<td>Suitable</td>
</tr>
<tr>
<td>Potato</td>
<td>Not ideal</td>
<td>Not ideal</td>
<td>Suitable</td>
</tr>
<tr>
<td>Banana</td>
<td>Suitable</td>
<td>Suitable</td>
<td>Suitable</td>
</tr>
<tr>
<td>Pawpaw</td>
<td>Suitable</td>
<td>Suitable</td>
<td>Suitable</td>
</tr>
<tr>
<td>Lychee</td>
<td>Suitable</td>
<td>Suitable</td>
<td>Suitable</td>
</tr>
<tr>
<td>Other tropical fruit</td>
<td>Suitable</td>
<td>Not ideal</td>
<td>Not ideal</td>
</tr>
<tr>
<td>Timber</td>
<td>Suitable</td>
<td>Suitable</td>
<td>Suitable</td>
</tr>
<tr>
<td>Bamboo</td>
<td>Suitable</td>
<td>Suitable</td>
<td>Suitable</td>
</tr>
<tr>
<td>Forage crops (maize, sorghum etc.)</td>
<td>Suitable</td>
<td>Suitable</td>
<td>Suitable</td>
</tr>
</tbody>
</table>

DAF also sponsored a study into fallow crops in the Burdekin district\(^{49}\), the results of which showed a better outcome with fallow crops than a bare/chemical fallow, assuming crop losses were not too high.

**FIBRE CROPS**

Fibre crops such as Kenaf\(^{50}\) and other hems were mentioned as a means for mills to extend asset utilisation into the non-crush season.

There is strong enthusiasm for fibre crops with some people, and the opposite view of 'we tried it, and we couldn’t make it work,' with others.

The issue would likely appear to be commercial, and market prices can change.

The issues raised were:

- The economics of fibre are better using an existing mill than building a new one.
- Use in the non-crush is complementary.
- Can be used in all sorts of existing and new materials, e.g. paper, building materials, fabrics, etc.


- Can require optimisation of the plant at the mill.

Like other opportunities, the business model would need to be defined more clearly for parties to go ahead with fibre crops.

**GMO, TRANSGENIC PLANTS & SYNTHETIC BIOLOGY**

Transgenic or GMO cane was a source of much discussion.

1. It was recognised that genetically modified (GM) cane could improve yields, sugar content, disease resistance and other aspects.
2. The now ended research on transgenic cane with DuPont was mentioned by several parties. It was recognised that a lot of the foundational research is in place.
3. There was recognition that a key barrier is the reluctance of international buyers to accept GM sugar. The regulators in customer countries would have to be convinced too.
4. CRISPR gene editing technology could provide new pathways.
5. Additionally, synthetic biology approaches could transform the way products are made from cane juice, sugar, molasses and fibre. For example, synthetic biology\(^{51}\) approaches could turn sugar or bagasse into pharmaceuticals or other high value add products.

**ANIMAL FEED**

Bagasse or cane trash-based animal/stock feed was mostly seen as a regional opportunity due to logistics costs. There are some issues around digestibility of trash and bagasse to be solved – mainly around the high fibre content\(^{52}\).

Molasses is already widely sold into the market. Raw sugar sales into the market were identified as a potential opportunity for further investigation.

A few participants thought that if a focus was on making animal feed, it should incorporate other non-sugar industry products to make a better product for the market. The thinking was that the sugar industry could take the lead and buy other products for incorporation.

The production of proteins via fermentation or via gasification of biomass was raised as known but were not a priority as of this date.

**ADDITIONAL INFORMATION**

The Food and Agriculture Organization projects that food production will have to expand by 70% to meet the projected demand for adequate nutrition\(^ {53}\).

An increase of 70% in production of meat, milk, and other animal products represents a significant challenge to feed production capacity. Protein is a key component of feed and the feed production sector is increasingly looking to the emerging bio-economy for new,


economic sources of protein. Sugarcane bagasse (raw or pre-treated), trash, and molasses are all potential substrates for protein production.

Further, energy products from sugarcane (including methane) are also potential substrates for feed protein production (e.g., Protelux has recently completed construction of a 6,000 tpa methane-to-protein plant54).

Using bagasse as animal feed is not new. In Brazil, bagasse was historically used as animal feed55 and until 1995, around 120 plants were equipped to treat raw bagasse so as to increase digestibility from a low of 30% to circa 65%. However, the number of facilities has since reduced somewhat as producers have redirected the same material to alternate ventures including co-generation of electricity. An interesting premise outlined in this study57 was that by using bagasse as an animal feed within the immediate region, this allowed traditional livestock farmers to intensify their operation rather than be displaced by an expanded sugar cane industry.

However, in those sugarcane crop residues containing intact or partially intact cell walls (i.e., tops, trash, and bagasse), the sugarcane-derived animal feed has a high lignin content, low level of soluble carbohydrates and relatively low levels of fermentable nitrogen and bypass protein act together to limit the efficiency with which ruminants and nonruminants can release the metabolic energy from these materials.

SRA is currently funding research exploring various pathways to utilise bagasse as an animal feed56. In its basic form, bagasse is a low-quality feed. An important study objective is to improve bagasse digestibility. In particular, two approaches are being explored: high temperature treatment and chemical ensilage, a process where an agent is added to the bagasse and it is allowed to sit at room temperature for a period of time.

TOPS AND TRASH

Growers were interested in what could be done with tops and trash. Options include stock feed, densified biomass, normal biomass for cogeneration or gasification, and providing it as cellulosic feedstock for biofuel and biochemical processes.

1. SRA has funded work on trash collection while harvesting to help with the economics57.
2. Tops and trash are left on the field to add water retention and retain nutrients in some areas. Perhaps not all the trash is required.
3. For some processes, such as densified biomass, the tops and trash need to be kept free of soil. Other processes are more robust.
4. Trash has a lower density than cane, so the transport costs are higher on a per tonne basis.

56 “A profitable future for Australian agriculture: bio-refineries for higher-value animal feeds, chemicals and fuels”, Milling Matters autumn 2017, Sugar Research Australia.
5. Harvesting the whole cane was mentioned as having been trialled before. The outcome, anecdotally, was that the higher salt content of the trash ended up in the sugar, and there were more losses of sugar to biomass.

6. The high salt content (e.g. potassium and chlorine) of trash is a known issue, and the trash will require pre-treatment to remove that for some processes. By comparison, bagasse is effectively steam treated in the normal processes at the mill and has had almost all the alkaline content removed.

Tops and trash represent an unused waste stream of the industry, one for which growers may be able to pursue to increase their sustainability without seeking changes to the cane payment formula or reducing the amount of cane going to the mills. Corporate growers such as the milling companies can also pursue these same opportunities.

BIOGAS, BIOMETHANE AND RENEWABLE HYDROGEN

Internationally there is growing interest in, and a market for, renewable methane also known as biomethane. Biomethane is biogas that has been cleaned up to meet the specifications of typical of natural gas customers.

Biogas is created using anaerobic digestion – using bagasse feedstock in an anaerobic digester, mixed with other feedstocks to optimise gas production. Biogas can be used locally for industrial processes involving boilers, stationary engines and turbines.

Gasification and pyrolysis can be used to create syngas (hydrogen and carbon monoxide) which can then be converted into biomethane, renewable hydrogen, or other products.

The gasification process can also be used to make renewable hydrogen, which could be of value for use in hydrogen powered cars and trucks.

The uptake of biogas will rely on the economics of production, including having a customer nearby, unless there is sufficient margin to process and clean up the biogas to make biomethane and put it in a gas pipeline.

SRA has been funding research into biogas through the Biogas from Sugarcane program. Separately, the University of Southern Queensland undertakes biogas research and offers services through their National Centre for Engineering in Agriculture.

International research has looked into producing biogas via anaerobic digestion of vinasse, as well as gasification of bagasse and cane trash to generate electricity in a gas turbine.

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61 Moraes, B.S., Zaiat, M., and Bonomi, A., 2015, Anaerobic digestion of vinasse from sugarcane ethanol production in Brazil: Challenges and perspectives, Renewable and Sustainable Energy Reviews, Vol. 44.

KNOWLEDGE PROVIDER

While there is no simple definition of knowledge provider, the following themes were raised as useful roles for SRA, to one degree or another.

1. A source of information for growers, which to be fair SRA already does. The interpretation of conversations on this were that perhaps other organisations do this better, e.g. for cotton and grains. Part of these discussions recognised the need to bring in new, younger growers, and that many growers are time poor, needing to work a second job just to remain viable.

2. A source of information to help inform regulatory reforms. This was a contentious topic, with some saying SRA isn’t the right party to advise government, and others saying it could help with research.

3. Helping the whole industry engage in the transition to digitalisation, including the role out of Internet of Things (IoT) and other forms of measurement and optimisation.

4. Helping retain knowledge on the milling side of the industry. There is a perception that much of the knowledge on how to best run and maintain mills will soon be lost as people retire. The question was raised on how that information can be captured, retained and passed on to new people entering the industry.

5. There is a role for cross-disciplinary work on industry improvements. A few parties suggested that there have been many advances in process engineering and technology in other. Likewise, optimisation using industrial mathematics has greatly improved which could improve many areas of the supply chain.

6. SRA could become a premier sugar industry knowledge provider globally given the large investment in R&D to date. This is acknowledged as contentious as on the one hand we don't want to be seen to be giving up our lead in areas such as yield per hectare, however, there was acknowledgement that many of the other innovations in the industry are coming from overseas. One view was that given the level of foreign ownership, this transfer is happening anyway, so why not formalise and monetise it.

7. Providing consulting services locally or in the international market.

8. A source of information on research in relevant areas in Australia and internationally. It was suggested that perhaps an annual summary could be published, and this would be aided by the contacts that existing researchers have.
5. Industry Priorities

Industry priorities have been established based on the breadth and strength of interest within the industry. The industry priorities recommended match have been matched against the potential role for SRA.

INDUSTRY DISCUSSIONS – UNFILTERED

Going into the consultation process, it was thought that industry participants would provide specific products (e.g. succinic acid, lignin, etc.) as priorities to guide SRA in its research.

What happened in the meetings was instead a wide-ranging discussion of the large number of opportunities previously evaluated and a discussion on what could help reduce uncertainty for industry.

The key topic of discussion across meetings was in fact harvest losses/mill gains, which is a short-term potential gain for the industry. There was also robust discussion on adoption of farming systems and BMP uptake as near-term potential gains.

We interpret this focus on reducing losses and increasing yields as near term, relatively low risk matters for industry to improve throughput and reduce costs, with value add and diversification seen as medium to longer term opportunities.

The top two requests for a service from SRA were to provide a market watch and technology watch service. These are discussed further below.

OPPORTUNITIES PRESENTED FOR DISCUSSION

There are a large number of value add and diversification opportunities available to the sugar industry. The following visualisation of value add and diversification opportunities was prepared and provided as part of the background briefing document. While it omitted a few key opportunities such as food products, alcohol and other crops (supplementary, fallow, etc.) it did provide a good basis of discussion.
RANKING PRODUCT OPPORTUNITIES

To aid with the ranking of industry priorities the following methodology was used.

1) Meeting records were reviewed in detail and summarised.
2) A rating was developed for breadth of industry interest, considering the parties and their size in industry.
3) A rating was developed for the level of industry interest.
4) The opportunities discussed were scored, then moderated taking into account the size of the organisations providing those views.

The following qualitative scales were used to rank projects, the results of which are shown in the Figure 9.
Table 4- Qualitative scales used to rank opportunities

<table>
<thead>
<tr>
<th>Scale</th>
<th>Breadth of Interest</th>
<th>Level of Interest</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Some individuals or organisations expressed an interest.</td>
<td>Little interest expressed in the near term. Known as an opportunity, but perhaps not being actively pursued.</td>
</tr>
<tr>
<td>3</td>
<td>Half of the relevant industry stakeholders expressed an interest in the topic.</td>
<td>Moderate interest shown in a topic. Potentially a topic previously looked at but not yet known to be commercial.</td>
</tr>
<tr>
<td>5</td>
<td>Most, if not all organisations and relevant industry stakeholders expressed an interest.</td>
<td>A topic of strong interest, with near term potential.</td>
</tr>
</tbody>
</table>

The values of 2 & 4 on the scale provide intermediate points to rank opportunities.

The data points on the following graph have been deliberately separated from each other to provide clarity to outcomes.

Those opportunities on the top right represent those with both the greatest breadth and level of interest and represent interest priorities.
Figure 9 – The industry view on opportunities – ranked by breadth and level of interest
The focus was narrower than anticipated – largely on proven technologies with market risk.

Ethanol
Densified Biomass
Cogeneration, plus
Food products
Final report: Industry priorities for value add & diversification opportunities in the sugar industry

Figure 11 – Opportunities of merit, but not top priorities

Typically regionally specific.

Some interest in future technologies, but not a key focus.

As a value-add to sugar or cane juice.

Recognised as largely proprietary IP with potentially hundreds of technology developers.

Consequently, industry has more of a ‘wait and see’ approach.

There was recognition of other opportunities, but not as an industry wide priority.

Chemicals from sugar

Animal feed
An interesting outcome was the lack of specific opportunities in 2nd generation technologies which use biomass as a feedstock. Based on the consultation sessions and our industry knowledge this was interpreted as industry participants recognising the high level of technical and market risk attached to these processes, which was expressed as a desire for help with the market watch and technology watch services from SRA.

Fallow crops are of interest but don't rate as a top priority, largely as fallow crops are already being pursued across industry. One of the main issues raised was the need for infrastructure such as processing plants and storage, to improve the viability of those crops.

Late in the consultation process SRA’s constitution was changed to allow for services for a fee, breaking with the traditional levy only based approach. This was picked up and discussed by only a couple of participants at the end of the consultation process. We think that this change could be quite profound and fits well with a so-called ‘knowledge provider’ role.

The theory is that SRA not only has developed its own knowledge and IP, but it also is the holder of knowledge and IP from prior industry bodies such as BSES, SRDC, the CRC for Sugar Based Biotechnology. This knowledge base is world class and represents a foundation for services to domestic and international organisations. As such, we have elevated this to one of the top industry priorities.
INDUSTRY PRIORITIES – PRIOR TO MODERATION

If we include discussions on harvest, farm systems and being a knowledge provider, the greatest topics of interest in the industry are as follows.

Table 5 – Industry priorities, prior to moderation, and desired outcomes

<table>
<thead>
<tr>
<th>Industry Priorities</th>
<th>Desired outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Harvest losses/mill gains</td>
<td>Prove the benefits to mills and growers once and for all. The most talked about topic, with a wide range of views.</td>
</tr>
<tr>
<td>2 Farm systems/BMP uptake</td>
<td>SRA developed the knowledge. Broader adoption uptake will show the benefits.</td>
</tr>
<tr>
<td>3 Market Watch</td>
<td>Revenue focus - We know the products, but we need to know we’ll make money before we invest.</td>
</tr>
<tr>
<td>4 Technology watch</td>
<td>Cost and technology risk focus – Cheaper and better ways to make new products.</td>
</tr>
<tr>
<td>5 Knowledge provider</td>
<td>New consulting focus – SRA can directly help industry partners, also, can earn more revenues (international too?)</td>
</tr>
<tr>
<td>6 Cogeneration</td>
<td>Proven option. Uncertain about the electricity market. Value add for fly ash an option.</td>
</tr>
<tr>
<td>7 Ethanol</td>
<td>Proven option. Uncertain about E10 Mandates – domestic and international</td>
</tr>
<tr>
<td>8 Densified biomass (pellets, briquettes, etc.)</td>
<td>Potential Option – Bagasse and cane trash to make a renewable replacement for coal for power and steel making.</td>
</tr>
<tr>
<td>9 Food products – value adding to the sugar itself.</td>
<td>Know your customers better, make what they want – whether it is value added sugar, or other food products.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Secondary Priorities</th>
<th>Desired Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 Complementary Crops (Sweet sorghum, energy cane and agave)</td>
<td>Agronomy and processing focus. Can we make money out of it? How do we grow it, harvest it, process it, and monetise it? What varietals work?</td>
</tr>
<tr>
<td>11 Chemicals from sugar</td>
<td>Process improvement – optimising, improving known fermentation processes.</td>
</tr>
<tr>
<td>12 Animal Feed</td>
<td>New product focus. How can we make feed from bagasse, molasses, sugar and other ingredients/feedstocks? Fermentation of sugar, and gasification to protein pathways also of interest as new products/processes.</td>
</tr>
</tbody>
</table>

NON-VALUE ADD AND DIVERSIFICATION PRIORITIES

The purpose of this project is to identify industry priorities for SRA to deliver on Key Focus Area 6 (KFA6) – value add and diversification.

To that end, the following topics, while of great interest across the industry in the near term, are removed from the list of priorities for SRA to consider for assistance under KFA6:
• Harvest losses/mill gains – while there are genuine questions and improvements to be made, these are mostly already covered under other key focus areas within SRA. Given that this was the most discussed opportunity and also the topic with the widest range of views, there appear to be further opportunities for SRA to put this issue to rest.
• Farm systems/ BMP uptake – a known issue covered under other KFA.
• Knowledge provider/consultant – this would appear to be mostly covering company specific issues rather than industry wide priorities. The knowledge held by SRA on the topics of value add and diversification are valuable, but likely with relation to specific opportunities rather than industry wide opportunities.

INDUSTRY PRIORITIES – RECOMMENDATIONS FOR SRA

When looking at what SRA could provide RD&A services for the industry, ethanol stands out as being problematic. The reason being that ethanol production is probably the oldest chemical process used by humankind, and large R&D dollars are invested in incremental process improvements. Supplementary sources of sugar from agave and sweet sorghum make sense as a means to obtain better asset utilisation.

In addition, high fibre, so called energy canes could be used in densified biomass, and cogeneration.

Consequently, in these final recommendations, ethanol has been dropped as a discrete topic, and complementary crops included, with an initial preference for sweet sorghum, noting that sweet sorghum, agave and energy cane all have comparative advantages in different regions.

Table 6 – Recommended Industry Priorities for SRA

<table>
<thead>
<tr>
<th>Industry Priorities</th>
<th>Potential SRA role</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 Technology watch</td>
<td>Knowledge. Use existing contacts in industry – publish curated and collated updates.</td>
</tr>
<tr>
<td>3 Densified biomass (pellets, briquettes, etc.)</td>
<td>Process research. Potential for targeted research on treatment, pelletisation/extrusion, and dehydration processes in order to reduce capital and operating costs. The role of complementary crops could be included in research.</td>
</tr>
<tr>
<td>4 Food products – value adding to the sugar itself.</td>
<td>Product development. Helping meet market needs. From fundamental research to helping develop products for end users. Could also cover agave and sweet sorghum sugars.</td>
</tr>
<tr>
<td>6 Complementary crops (Sweet Sorghum, Agave)</td>
<td>Complementary crop development. Help industry select varietals, develop farm management systems, develop food products and supporting processes, identify and quantify mill modification requirements, plus processes for producing non-food products (ethanol, cogeneration, densified biomass). Techno-economic analysis of the whole system.</td>
</tr>
</tbody>
</table>
### Secondary priorities & Potential SRA Role

<table>
<thead>
<tr>
<th>Priority</th>
<th>Secondary priority</th>
<th>Potential SRA Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Chemicals from sugar</td>
<td><strong>Process research</strong> Market watch and technology watch could help keep industry informed. From fundamental research to helping develop products for end users, potentially limited by available budget.</td>
</tr>
<tr>
<td>8</td>
<td>Animal Feed</td>
<td><strong>Product Development.</strong> Working with specialist to identify what combinations of sugar industry by-products and other inputs could be used. Work on making proteins from sugars, or via gasification pathways could also be of interest.</td>
</tr>
</tbody>
</table>

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**OTHER KEY DISCUSSIONS - RISK ATTITUDES, COMMERCIALISATION TIMEFRAMES, & INTERNATIONAL COLLABORATION**

**RISK ATTITUDE**

The levels of risk industry are willing to consider are informative. Specifically, participants were asked about the scale of opportunity they were interested in, and also their attitudes towards 3rd parties. The results, which are indicative only, are as follows.

*Figure 12 – Industry Risk Attitudes*

![Industry Risk Attitudes - Scale & Ownership](image)

Incremental opportunities allow for greater risk taking. They allow for experimentation without betting the whole business on the outcomes. They also allow for additional revenue sources from multiple sources.

Game changing opportunities imply a low risk, financially certain structural change in what is made from cane. Such an opportunity would likely be high cost, and an organisation and its Board would likely require high certainty on both technical and market risks.

Both views make sense. The industry has, as a whole, investigated numerous opportunities in the past with very little actually being confirmed as viable, and no game changers identified. Taking an incremental approach could be sensible, taking smaller bets, and achieving as much additional revenue as possible. On the other hand, the amount of
organisational time and effort dedicated to smaller projects could be considered costly and putting those same resources into larger projects could be considered a rational.

The ownership of plant is an interesting question. The industry priorities show preferences for products that organisations can implement on their own. There was little appetite for products where the technology still unproven and for which the market is still uncertain.

For example, according to Biofuels Digest63, there are some 900 bioeconomy projects planned around the world, which represent the efforts of many companies looking to commercialise their IP, few of which have adequately reduced the technical risks to a level acceptable by industry.

The feedback received from within industry is that inventors and small organisations routinely contact the mills and sometimes the growers directly. They typically are looking to build a pilot or demonstration plant for their technology, which haven’t yet been proven to work at scale. For new products, there is also often considerable pricing risk for the output of the plant.

These smaller organisations also often ask for cheap feedstock (cane juice, sugar, bagasse, etc.) as well as steam, electricity and land on site. However, the likelihood of commercial success for many of these technologies is as yet unknown.

On the other side if mills, in particular, are averse to taking technical and market risk, then it would make sense for them to engage with 3rd parties willing to take on that risk.

The results of this consultation suggest that the industry would like to do projects themselves and are, pragmatically, asking for the market and technology watch services from SRA in order to help them remain informed when opportunities arise in the future.

INTERNATIONAL COLLABORATION

The above also led to a good discussion on the potential of greater international collaboration.

1) It allows SRA to spread its risk by placing smaller bets on multiple products and pathways.
2) By co-investing with industry, it is investing in technologies that industry is supporting, rather than that which is promoted solely by researchers.
3) It provides a value for money outcome.
4) It may allow for reduced rates of royalties or technology licence fees for Australian sugar industry members to build plants using that technology.
5) It recognises that for some second-generation technologies the competitors are other sources of feedstock rather than other producers of bagasse. Working together to ensure that sugar industry feedstocks are commercially viable could be a good outcome.

LONG LEAD TIMES FOR COMMERCIALISATION

There was surprisingly little request for SRA to investigate new products.

The following reasons were stated:

1) There is a lot of research happening domestically and globally.
2) There are potentially hundreds of companies trying to commercialise their IP.
3) It takes many years, and deep pockets to commercialise any single product, and there is no guarantee of success.
4) Hundreds of millions of dollars are being spent on improving existing processes, e.g. higher yielding yeasts and enzymes for ethanol production.

The following image (Figure 13) from the background brief was used to provide an illustrative view on how long it takes to commercialise a new product or process.

The key takeaways are:

1) Many technologies are effectively stuck in the laboratory. They achieve good technical results at that scale but fail to make it to a pilot scale.
2) Anecdotally, equity investors are unlikely to invest in projects prior to the demonstration scale, with a pilot scale plant required to prove technical viability.
3) Buyers and financiers typically require at least one commercial scale reference plant before buying or investing in a technology. This requires the technology and market risks be reduced to an acceptable level for investment.
4) Many of the technologies already at commercial scale have failed to work commercially. E.g. the yields are too low, the market doesn’t support viability or other risks, potentially in combination.
Figure 13 – The four steps to commercialisation

1. Laboratory
   - From idea to proving parts of the process, optimising and developing initial plant design. Process runs in batches.
   - Cost: $100,000 - $1 M
   - Funding from gov’t, universities and corporate R&D.

2. Pilot
   - Technical proof of concept. Run on a continuous basis to test, optimise and prove up the process. Product tested against relevant standards.
   - Cost: $1 M to $5 M
   - Difficult to fund. Some Gov’t support.

3. Demonstration
   - Commercial proof of concept. Full plant, but at sufficient scale to lower financial risk and prove ability to scale up volumes while maintaining process efficiency and costs.
   - Cost: $5 M to $30 M
   - Funding from private equity and government. On balance sheet funding for larger corporations

4. Commercial Scale
   - Commercially viable plant, operating life of 20 years. One plant operating successfully at commercial scale is the requirement for adoption across industry.
   - Cost: >$50 M
   - Funding from owner equity, institutional equity, banks and government agencies.

As a rule of thumb, each step should be 10 times larger than the last.

New process – 8 to 15 years
Incremental improvements to existing processes – 2 to 5 years
6. Conclusions

There are significant resources available to the sugar industry, not all of which are used for value add and diversification activities.

The following shows the 2017 mass balance for feedstock, products and by-products.

*Table 7 – 2017 Sugar Industry Mass Balance*

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Unit</th>
<th>Approx. t / ha</th>
<th>Industry quantity</th>
<th>Industry revenue $’Million</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>On farm</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cane trash</td>
<td>Mt</td>
<td>12.5</td>
<td>4.70 Mt</td>
<td>-</td>
</tr>
<tr>
<td>Cane billets</td>
<td>Mt</td>
<td>88.4</td>
<td>33.34 Mt</td>
<td>1,356</td>
</tr>
<tr>
<td><strong>SUB TOTAL</strong></td>
<td></td>
<td>100.9</td>
<td>38.04 Mt</td>
<td>1,356</td>
</tr>
<tr>
<td><strong>At mill</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raw sugar</td>
<td>Mt</td>
<td>11.87</td>
<td>4.48 Mt</td>
<td>1816</td>
</tr>
<tr>
<td>Molasses</td>
<td>Mt</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Export</td>
<td>Mt</td>
<td>2.63</td>
<td>0.53 Mt</td>
<td>72</td>
</tr>
<tr>
<td>Ethanol distillation (approx.)</td>
<td>Mt</td>
<td>0.23</td>
<td>0.23 Mt</td>
<td>31</td>
</tr>
<tr>
<td>Other (approx.)</td>
<td></td>
<td>0.25</td>
<td>0.25 Mt</td>
<td>34</td>
</tr>
<tr>
<td>Mud &amp; boiler ash</td>
<td>Mt</td>
<td>5.34</td>
<td>2.02 Mt</td>
<td></td>
</tr>
<tr>
<td>Waste water</td>
<td>GL</td>
<td>56.11</td>
<td>22.0 GL</td>
<td></td>
</tr>
<tr>
<td>Bagasse</td>
<td>Mt</td>
<td>12.4</td>
<td>4.67 Mt</td>
<td></td>
</tr>
<tr>
<td>Export energy</td>
<td>GWh</td>
<td>n/a</td>
<td>1,770 GWh</td>
<td>191</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td></td>
<td></td>
<td>2,137</td>
</tr>
</tbody>
</table>

Beyond physical commodities, other resources of interest in value add and diversification include:

- Land under cane is 377,000 Ha.
- Mills are a good central location where feedstocks are co-located with land, electricity, skilled workforce, steam and an electrical connection.
- Feedstock logistics can be made available during the non-crush, including:
  - 4000 km of rail
  - 250 diesel-hydraulic locomotives
• Offtake logistics for bulk commodity handling are in place with the 6 sugar export terminals
• 487 MWe electricity generation capacity (excluding the Tablelands cogeneration upgrade).

At the commencement of this study, it was assumed that there were specific products or chemicals that industry would set as a priority. The discussions held with industry participants were wide ranging and quite broad, with much of the emphasis on helping resolve uncertainties, and on a few key topics.

The top two topics were a market watch and a complementary technology watch. This reflects the industry view that there are no shortage of opportunities and the industry will invest when they think they can make a profit.

The full list of value add and diversification topics raised by industry, in no particular order, is:

1. Market watch
2. Technology watch
3. Sugar as a food product
4. Cogeneration
5. Industrial ethanol
6. Densified biomass (bagasse & trash)
7. Chemicals from sugar
8. Chemicals from biomass
9. Rum and other spirits
10. Energy cane
11. Sweet sorghum
12. Fallow year crops
13. Fibre crops
14. GMO, transgenic plants and synthetic biology
15. Animal feed
16. Tops and trash
17. Biogas, biomethane and renewable hydrogen
18. Knowledge provider

Considerable discussion was held on framing issues for the sugar industry, including the following three.

• Harvest losses/mill gains – while there are genuine questions and improvements to be made, these are mostly already covered under other key focus areas within SRA. Given that this was the most discussed opportunity and also the topic with the widest range of views, there appear to be further opportunities for SRA to put this issue to rest.
• Farm systems/ BMP uptake – a known issue covered under other KFA.
• Knowledge provider/consultant – this would appear to be mostly covering company specific issues rather than industry wide priorities. The knowledge held by SRA on the topics of value add and diversification are valuable, but likely with relation to specific opportunities rather than industry wide opportunities.
An interesting outcome was the lack of specific opportunities in 2nd generation technologies which use biomass as a feedstock. Based on the consultation sessions and our industry knowledge this can be interpreted as industry participants recognising the high level of technical and market risk attached to these processes, which was expressed as a desire for help with the market watch and technology watch services from SRA.

Fallow crops were of interest but don’t rate as a top priority, largely as fallow crops are already being pursued across industry. One of the main issues raised was the need for infrastructure such as processing plants and storage, to improve the viability of those crops.

Agave as a crop does seem to have good potential, however, it is mostly as a dry land crop, and as such, sweet sorghum would appear to be more applicable to the industry as a whole.

The risk attitudes of industry are informative. We asked participants about the scale of opportunity they were interested in, and also attitudes towards 3rd parties. The results, which are indicative only, are as follows.
Regarding the scale of opportunity, both views make sense. The industry has, as a whole, investigated numerous opportunities in the past with very little actually being confirmed as viable, and no game changers identified. Taking an incremental approach could be sensible, taking smaller bets, and achieving as much additional revenue as possible. On the other hand, the amount of organisational time and effort dedicated to smaller projects could be considered costly and putting those same resources into larger projects could be considered a rational decision.

The results of this consultation suggest that the industry would like to do projects themselves, and are, pragmatically, asking for the market and technology watch services from SRA in order to help them remain informed when opportunities arise in the future.

There was little interest by industry participants in SRA researching new products or processes. There was recognition that hundreds of millions of dollars are being spent in the bioeconomy with some 900 or so companies seeking to commercialise their technology and products. There was also recognition that the industry would like assistance in the near term and that the 8-15 year timeframe for commercialisation did not match their needs.

On a related point, the potential for SRA to seek international collaboration was raised as a means for SRA to leverage its funds as best as possible.
## A. Appendix A – List of consultation participants

The following is the complete list of consultation sessions, ordered by date.

<table>
<thead>
<tr>
<th>Date</th>
<th>Organisation</th>
<th>Attendees</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 August 2018</td>
<td>CANEGROWERS</td>
<td>Matt Kealley - Senior Manager for Environment and Sustainability</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Burn Ashburner - Senior Manager - Industry</td>
</tr>
<tr>
<td>30 August 2018</td>
<td>ACFA</td>
<td>Stephen Ryan - General Manager ACFA</td>
</tr>
<tr>
<td>5 September 2018</td>
<td>ASMC</td>
<td>David Pietsch - CEO ASMC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Jim Crane - Director Industry &amp; Government Relations</td>
</tr>
<tr>
<td>7 September 2018</td>
<td>Sugar Research Institute</td>
<td>David Green – General Manager</td>
</tr>
<tr>
<td>11 September 2018</td>
<td>MSF/Mitr Phol</td>
<td>Hywel Cook – General Manager Business Development</td>
</tr>
<tr>
<td>14 September 2018</td>
<td>Queensland Government</td>
<td>Michael Burke - Director Biofutures Queensland - DSDMIP</td>
</tr>
<tr>
<td></td>
<td>Department of Agriculture and</td>
<td>Kym Coyne - A/Director Strategy Coordination and Skills</td>
</tr>
<tr>
<td></td>
<td>Fisheries (DAF)</td>
<td>(DAF)</td>
</tr>
<tr>
<td></td>
<td>Department of State Development,</td>
<td>Meagan McKenzie – A/Regional Director – South East (DAF)</td>
</tr>
<tr>
<td></td>
<td>Manufacturing, Infrastructure and</td>
<td>Elton Miller ED - industry development arm. (DAF)</td>
</tr>
<tr>
<td></td>
<td>Planning (DSDMIP)</td>
<td></td>
</tr>
<tr>
<td>18 September 2018</td>
<td>University of Queensland</td>
<td>Professor Lars Nielsen</td>
</tr>
<tr>
<td>21 September 2018</td>
<td>Wilmar Sugar Australia</td>
<td>Mark Moriarty – Manager, Business Development</td>
</tr>
<tr>
<td>9 October 2018</td>
<td>CANEGROWERS</td>
<td>Kevin Borg (Chair) - Mackay</td>
</tr>
<tr>
<td></td>
<td>Farm Inputs &amp; Research Committee</td>
<td>Glen Clarke - Proserpine</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Michael Pisano – Herbert River</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Jeff Atkinson - Maryborough</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tom Harney – Tully</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Steve Pilla – Burdekin</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Burn Ashburner - Brisbane</td>
</tr>
<tr>
<td>10 October 2018</td>
<td>Farming for the Future</td>
<td>Les Nielsen</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lance Rodman</td>
</tr>
<tr>
<td>10 October 2018</td>
<td>Milling Consultant</td>
<td>Jeff Snoad</td>
</tr>
<tr>
<td>9 November 2018</td>
<td>North Queensland Bio Energy</td>
<td>Robert Carey - CEO</td>
</tr>
<tr>
<td>14 November 2018</td>
<td>CANEGROWERS</td>
<td>Cameron Waterson (DM) - Maryborough</td>
</tr>
<tr>
<td></td>
<td>Policy Meeting</td>
<td>John Eden - Mackay</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Maria Battoraro - Herbert River</td>
</tr>
<tr>
<td>Date</td>
<td>Company</td>
<td>Key Person</td>
</tr>
<tr>
<td>-------------------</td>
<td>----------------------------------------</td>
<td>-------------------------------------</td>
</tr>
<tr>
<td>20 November 2018</td>
<td>Isis Mill</td>
<td>John Gorringe - CEO</td>
</tr>
<tr>
<td>20 November 2018</td>
<td>Queensland Renewable Fuels Association (QRFA)</td>
<td>Larissa Rose – Managing Director</td>
</tr>
<tr>
<td>22 November 2018</td>
<td>MSF/Mitr Phol</td>
<td>Mike Barry – CEO</td>
</tr>
<tr>
<td>23 November 2018</td>
<td>Bundaberg Sugar</td>
<td>Gary Nixon - Chief Operating Officer of Bundaberg Sugar</td>
</tr>
<tr>
<td>23 November 2018</td>
<td></td>
<td>Neil Sichter - Process Technology Manager - Bundaberg Walkers</td>
</tr>
<tr>
<td>23 November 2018</td>
<td></td>
<td>Enio Troiani - General Manager - Bundaberg Walkers</td>
</tr>
<tr>
<td>28 November 2018</td>
<td>Sunshine Sugar</td>
<td>Chris Connors - CEO</td>
</tr>
<tr>
<td>28 November 2018</td>
<td></td>
<td>Kent Selby - Manager Diversification</td>
</tr>
<tr>
<td>28 November 2018</td>
<td></td>
<td>Daniel Rojo - Technical Services Manager</td>
</tr>
<tr>
<td>5 December 2018</td>
<td>Dalby Biorefinery Limited (DBRL)</td>
<td>Gavin Hughes - CEO</td>
</tr>
<tr>
<td>10 December 2018</td>
<td>Joe Muscat</td>
<td>Joe Muscat – Cane grower, Mackay</td>
</tr>
<tr>
<td>10 December 2018</td>
<td>Mackay Sugar</td>
<td>John Hodgson – Business Development Manager</td>
</tr>
<tr>
<td>10 December 2018</td>
<td>Willmar Sugar Australia</td>
<td>Jay Venning – General Manager Production &amp; Technology</td>
</tr>
<tr>
<td>11 December 2018</td>
<td>The Product Makers</td>
<td>Barry Kitchen – Bio Actives Division</td>
</tr>
<tr>
<td>11 December 2018</td>
<td>Kevin Mann</td>
<td>Kevin Mann – Farmer &amp; Harvester</td>
</tr>
<tr>
<td>12 December 2018</td>
<td>Tully Mill</td>
<td>Shunjie Guo – CEO</td>
</tr>
<tr>
<td>17 December 2018</td>
<td>Uniquest</td>
<td>Deon Goosen – Director, Commercial Engagement – Agriculture and Food Sciences</td>
</tr>
<tr>
<td>17 January 2019</td>
<td>Queensland Sugar Limited</td>
<td>Greg Beashell - CEO</td>
</tr>
</tbody>
</table>
B. Appendix B – Background Brief to the Consultation Process

The following is the background brief as finalised 11 November 2018 and provided to participants in advance of consultation.