# REVISED FINAL REPORT

## Opportunities for the Australian sugar industry in greenhouse gas abatement and carbon trading: revised final report QUT027

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Sugar Research Australia™

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# SRA Research Project
# Final Report

Sugar Research Australia
Research Funding Unit

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| SRA project number: | QUT027 |
| SRA Project title: | Opportunities for the Australian sugar industry in greenhouse gas abatement and carbon trading |
| Name(s) of the Research Organisation(s): | Queensland University of Technology (QUT) |
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| A statement of confidentiality: | This a public version of the Final Report. The complete final report is confidential to QUT and SRA. It contains commercially sensitive data obtained from the two candidate mills and associated growing and harvesting operations involved in the regional case studies undertaken as part of this project. In addition this report contains information on the Life Cycle Assessment template which if released would reduce the commercial value of the template as a consulting tool. Parties will not publish or distribute copies of the Final Report without written approval from each other. |

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

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

## Non-confidential summary

New policies and market drivers are currently being implemented to stimulate additional investment in technologies and energy sources which result in reduced greenhouse gas emissions. In addition there is a rising demand from stakeholders and customers for information about the life cycle greenhouse gas emissions of products (carbon footprint).

A spreadsheet based template for the accurate and consistent Life Cycle Assessment (LCA) of sugarcane growing, milling, refining and distilling operations has been developed. The template performs material and energy balance calculations to produce data that can be used to conduct a full carbon footprint using commercially available LCA software. The tool enables a rapid and relatively low cost LCA evaluation of multiple scenarios relating to farming, harvest and transport practice, factory configuration, co-process integration strategies and the impact of extraneous fuels on the embodied emissions of cane products.

By way of demonstration, the model has been applied to two regional case studies. Carbon footprints were generated for products from two mills in the Burdekin and Mackay regions selected to represent significantly contrasting scenarios. In terms of farming and harvesting operations the majority of cane (91% for the mill considered) in Mackay is harvested green; in the Burdekin the majority of cane (100% for the mill considered) is burnt prior to harvest. On the processing side the Mackay case study considers a high degree of product diversification and process integration; the Burdekin case is focussed on maximising renewable power export. These case studies reinforced the importance of regional differences in farming operations as being the primary influencing factor in all food and energy related products. The case studies also provided quantitative evidence for the Greenhouse Warming Potential (GWP) benefits of replacing coal with surplus bagasse from surrounding mills for the provision of supplementary fuel.

The customised LCA software provides the processing sector with a powerful tool for and reduces the cost associated with quantifying the GWP associated with raw and refined sugar, molasses, electricity and ethanol.

# 1. Background:

The world is facing a future of unprecedented energy demand combined with the need for severe reductions in atmospheric carbon emissions. New actions and policies have been implemented by recent federal governments as a means of stimulating additional investment in technologies and energy sources with reduced emissions including renewable power and biofuels. These actions have included ratification of Australia's Kyoto emissions target, an increase in the Mandated Renewable Energy Target (for renewable power generation and solar hot water), the introduction of the Carbon Farming Initiative and most recently the Federal Government's proposed Direct Action plan (Anon, 2010). The emergence of an international carbon market will require an increased need for certification of renewable energy products and a more complete understanding of their associated life cycle emissions. With the growing awareness of climate change there has also been an increased demand from consumers and stakeholders for information about the greenhouse gas (GHG) emissions associated with products (carbon footprint).

***The sugar industry has the potential to be a major renewable energy producer and contribute significantly towards achieving national carbon emission reduction targets.*** Studies carried out by Dixon *et al.* (1998) at the former Sugar Research Institute (SRI) estimated that with the use of advanced cycle power generation and partial utilisation of cane harvest residues the (Queensland) sugar industry has the potential to displace up to 12% of carbon dioxide ($CO_2$) emissions from Australia's (2005) coal fired power plants. Early SRI studies under Sugar Research and Development Corporation (SRDC) projects QUT008 (2007) and CSE010 (2005) clearly identified that the then Mandated Renewable Energy Target (MRET) of 9,500GWh was inadequate as a driver to achieve this potential although subsequent to these studies the federal government raised the MRET to 60,000GWh. These changes re-define the economics of renewable power generation.

***There is a need for consistency in both the approach taken and underlying data used in the outward provision of GHG emissions associated with Australian sugar cane products.*** A CSIRO/ ABARE/ BTRE[1] study (Beer *et al.* 2003) on a 350ML biofuels target identified projected avoided emissions of 184,000 tonnes of $CO_2$ (in 2010) associated with the use of ethanol derived from a range of sugar and starch feedstocks. This analysis assumed high upstream emissions for the production of ethanol from C molasses; emissions more consistent with the production of ethanol from other feedstocks. A re-working of this analysis (Edye 2005) which included alternative assumptions and models (developed by SRI under the Sugar Industry Renewable Energy program) predicted an additional 42% avoided emissions for ethanol produced in the sugar industry compared to ethanol production from other feedstocks which require significant non-renewable energy inputs for processing.

[1] CSIRO (Commonwealth Scientific and Industrial Research Organisation), BTRE (Bureau of Transport and Regional Economics) and ABARE (Australian Bureau of Agricultural and Resource Economics)

This project addresses the need for a re-evaluation of and consistency in approach to determining the GWP of Australian sugar industry food and energy associated products in the light of emerging opportunities and consumer concerns related to $CO_2$ abatement.

## 2. Objectives:

The project objective is to maximise the industry's readiness to benefit from the introduction into the economy of greenhouse gas abatement mechanisms. This is achieved by:

- defining the carbon life cycle for a range of current and potential industry product mixes;
- providing the industry with a template for life cycle analyses of sugarcane growing, milling, refining and distilling operations for the analysis of individual company operations;
- reviewing current and projected state and federal government policies in relation to opportunities for renewable energy production and carbon trading;
- highlighting the potential carbon trading benefits of integrated sugar milling and renewable energy production;
- developing recommendations on ways in which the industry can derive maximum benefit from carbon trading and;
- collaborating via a linked UQ/ BSES project (UQ45) to establish a common database of whole-of-supply-chain embodied emissions and production data as a means of providing consistency between these and future analyses[2].

The originally defined objectives have been met as exemplified by the following project outputs.

- An Excel based template for LCA of sugarcane growing, milling, refining and distilling operations for the analysis of individual company operations has been developed. This template prompts the user or provides appropriate (default) raw input data required to undertake full life cycle analyses for raw sugar, refined sugar, ethanol and export electricity. The Excel template then undertakes material and energy balance calculations associated with a factory specific raw sugar production process and associated co-processes. The template generates an input file with a full

[2] The original proposal involved collaboration with a related Australian Sugar Milling Corporation (ASMC) project. This ASMC project did not eventuate whereas a UQ/ BSES project (UQ45) in which an LCA tool was developed for the sugar production process was initiated and provided complementary and essential input to this project (QUT027).

set of self-consistent inputs for LCA analysis using proprietary SimaPro LCA software.

- Two regional case studies have been undertaken using the Excel/ SimaPro tool. These case studies were able to demonstrate both the flexibility of the template in simulating the LCA of products from highly contrasting cane production practices, factory and co-process configurations, end products and supplementary fuels.

- A report was produced at an early stage in this project (August 2011) which documented state and federal government policies in relation to opportunities for renewable energy production (e.g. power export and biofuels) and carbon trading in the sugar industry. This document was reviewed by the project's Industry Review Group then amended and later updated (April 2013) to reflect developments in the (then) government's Carbon Pricing Mechanism (see Attachment A). With the advent of a new government following the 2013 federal elections, much of the legislation passed by the previous government in relation to their Carbon Pricing Mechanism is currently being rescinded. This final report documents the incumbent government's proposed new Direct Action scheme which replaces much of the legislation described in Attachment A.

The outputs from this project have been disseminated to the industry at three annual Regional Research Seminars conducted by QUT between 2011 and 2013. In addition papers have been presented at the 2013 Conference of the Australian Society of Sugar Cane Technologists and the 2013 Australian Bioenergy Conference describing the outputs of this project.

# 3. Outputs:

## 3.1 Software

The primary aim of this project has been to develop a tool that will enable rapid and consistent LCA of the main food and energy products associated with the sugarcane industry. This has been achieved with the development of an Excel based front end which interfaces with the commercially available SimaPro LCA software enabling LCA and carbon footprinting compliant with ISO14042 (Standards Australia, 1998) and ISO14064 (International Standards Organisation, 2006). The Excel based front end prompts the user for all data required to undertake a comprehensive LCA as well as providing region specific input data consistent with other sugar industry funded LCA tools and the Australian Life Cycle Inventory (AusLCI) database. A range of factory-integrated or stand-alone co-process configuration and feedstock scenarios can be readily set up using the Excel front-end. The software undertakes mass and energy balances to ensure self consistency in the product outputs before undertaking LCA.

### 3.2 Knowledge

The project has provided a new mass allocation methodology suitable for use across a range of sugar cane derived material and energy products. This methodology is consistent with but extends that used in determining emissions from CHP plants. Mass allocation factors reported in previous sugar cane LCA studies appear to significantly understate the emissions associated with electricity production and overstate those associated with the provision of process heat to the production of co-products. Although this new mass allocation methodology provides a sound physical basis for allocating GWP to sugar cane products it will increase the impact of low value by-products compared with economic allocation.

The two regional case studies provided detailed quantitative LCA data on the performance of two significantly different diversification scenarios for the Australian sugar cane industry and the GWP of the associated food and energy products. The case studies reinforced the importance of regional differences in farming operations as being the primary influencing factor in all food and energy products. The case studies also provided quantitative evidence for the GWP benefits of replacing coal with surplus bagasse from surrounding mills for the provision of supplementary fuel.

The collaboration between Chief Investigators and Industry Working Group members associated with this project and UQ045 (*Development of a streamlined life cycle assessment tool for assessing the environmental benefits of progressive sugarcane growing*) provided significant improvements in understanding of processes and practices across the growing and milling sectors of the industry.

## 4. Intellectual Property (IP) and Confidentiality:

The project IP generated by this project is the Excel based front end developed as a sugar industry customised interface to SimaPro LCA software. This IP is owned by Queensland University of Technology (QUT) and is protected by copyright.

Access to this software by the industry will be through the commissioning of QUT staff to undertake LCA work on a consulting basis. All revenue from these consulting activities will be directed towards further developing and refining this tool as well as maintaining a current SimaPro licence and associated LCA inventories as well as funding the ongoing representation of the sugar industry in the broader activities of the LCA community.

## 5. Environmental and Social Impacts:

This project is a desk-top study and does not pose any significant health and safety or environmental risks.

In a broader context the project is aimed at stimulating renewable energy production in the sugar industry, a development which may reduce the risk posed by greenhouse gas

emissions. Any increased economic activity associated with diversification of products from the sugar industry will deliver social benefits to regional communities.

## 6. Expected Outcomes:

The customised LCA tool for evaluating the GWP of sugar industry food and energy products provides the processing sector with a powerful tool for developing an understanding of the environmental impacts associated with these products. The LCA tool will significantly reduce the cost and improve the consistency of LCA analyses so that the industry can undertake[3]:

1. internal monitoring and management of impacts in order to:
    - identify emission 'hot spots' in cane production and processing;
    - evaluate improvement opportunities;
    - monitor and benchmark and;
    - inform purchasing choices associated with cane production and processing inputs;
2. the outward provision of information including:
    - being responsive to requests for information and data from customers/ stakeholders;
    - voluntary provision of information;
    - information on websites;
    - product labels and;
    - annual reports;
3. business development including:
    - carbon abatement opportunities (Carbon Farming Initiative, Direct Action and potentially future carbon trading schemes);
    - certification of products to environmental/ sustainability standards;
    - supporting product diversification and product development and;
    - informing/ influencing government policy.

[3] As summarised in Hobson and Renouf (2013)

## 7. Future Research Needs:

The following were identified during the course of the project as areas requiring further research and which were beyond the scope or resources of the current study:

- the need to develop a common data format for the transfer of intermediate outputs relating to production and harvesting operations from the CaneLCA tool developed under SRDC project UQ045 to the current Excel based tool;
- an extension of the ethanol production scenarios to include lignocellulosic production processes;
- an extension of the LCA tool to include the integration of other crops of interest (such as sweet sorghum) with sugarcane production and processing;
- improved regional, sugar industry specific data on $N_2O$ field emission factors and;
- improved data on soil carbon stocks and fluxes with transformation of land from agricultural cropping to either woodland or pasture and *vice versa*.

## 8. Recommendations:

In the context of the current policy environment around GHG abatement (i.e. the repealing of the Clean Energy legislative package) the detailed LCA tool developed in this project has limited application in providing guidance to the industry on the 'optimum' suite of energy and food products. Rather the LCA tool should be used to support the competitiveness of all sugar industry products on the international market where there is an increasing expectation that products meet prescribed sustainability standards including those associated with GWP. Inspection of the websites of some of the largest food and beverage manufacturers (such as Nestlé, Coca Cola and Unilever) indicates detailed reporting on environmental performance according to international standards such as the Corporate Standard and Product Life Cycle Accounting and Reporting Standard promoted by the GHG Protocol[4]. Organisations such as the Carbon Trust[5] offer internationally recognised accreditation for companies and products that meet prescribed sustainability criteria. Retail cane sugar supplied by Tate and Lyle has the Carbon Trust's Carbon Reduction Label displayed on the product packaging (Tate and Lyle, 2010).

In terms of cane derived fuel products there is significant effort currently being focussed on reaching consensus on international sustainability standards for biofuels through organisations such as the Roundtable on Sustainable Biomaterials[6]. Differing local standards for biofuels have been identified as a potential handicap to the international trade in this commodity.

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[4] See http://www.ghgprotocol.org/standards (referenced December 2013)
[5] See http://www.carbontrust.com/ (referenced December 2013)
[6] See http://rsb.org/ (referenced December 2013)

The use of locally developed customised software for the Australian sugar industry provides the industry with the best opportunity for ensuring the accuracy and controlling the outward provision of LCA data in promoting its products on the international market. It's in this context that the following recommendations are made.

- A funded program to benchmark the GWP of cane products from all Australian factories using the LCA tool developed in the current study. The results would be provided to participants on an anonymous basis (similar to the 'Mutual Control' program used to benchmark factory performance). This would allow factories to assess and look for ways of improving their environmental performance. The collated data would provide LCA data for the industry as a whole.

- The continued development and updating of a consistent set of sugar industry regional/ factory life cycle inventory data through participation in the Australian Life Cycle Inventory (AusLCI) Database Initiative[7]. This would be achieved through the routine submission of data collected during LCA studies undertaken (on a research or consulting basis) using the LCA tool.

- The further development of the LCA tool to report on a wider range of environmental impact factors (such as fossil fuel use, water use and water quality risk factors) consistent with the Cane LCA tool developed under SRDC project UQ045 (Renouf and Allsopp, 2013).

- The commissioning of a low level but ongoing watching brief on LCA developments in relation to sugar industry products and annual reporting to the industry through forums such as the Australian Society of Sugar Cane Technologists conference.

## 9. List of Publications:

Peer reviewed paper published in the conference proceedings of the Australian Society of Sugarcane Technologists (ASSCT); paper provided in Attachment C

> Hobson PA, Renouf MA (2013) *Development of a tool for rapid life cycle assessment of sugar and associated energy products* Proc Aust Soc Sugar Cane Technol Vol 35.

Paper delivered at Bioenergy Australia Conference, Hunter Valley; presentation provided in Attachment D.

> Hobson PA, Renouf MA (2013) *Development of tools for rapid and consistent life cycle assessment of sugarcane energy products*

[7] See http://alcas.asn.au/AusLCI/ (referenced December 2013)

Poster presented at Bioenergy Australia Conference, Hunter Valley

> Renouf M, Grant T, Hobson P, Eady S (2013) *New data and tools for LCA and carbon footprintin; supporting environmental assessments of bio-energy and bio-products*

Presentations at three annual Regional Research Seminars run by the Sugar Research and Innovation group within QUT. These seminars are held annually in five regions (Northern NSW, Bundaberg, Mackay, Burdekin and Cairns) and are typically attended by between 15 and 30 sugar factory managerial and technical staff.

## 10. Acknowledgements

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***Steering committee:***

Canegrowers- Bernard Milford, Jonathan Pavetto

ASMC– Sharon Denny

Mackay Sugar – John Hodgson

SRDC – Bianca Cairns, Ben Baldwin

## 11. References

Anon (2010). The Coalition's Direct Action Plan. Downloaded 20/10/2013 from http://www.greghunt.com.au/Portals/0/PDF/TheCoalitionsDirectActionPlanPolicy2010.pdf

Australian Government (2013). *National Greenhouse and Energy Reporting (Measurement) Technical Guidelines, July*. Downloaded 08/12/2013 from http://www.climatechange.gov.au/sites/climatechange/files/documents/07_2013/nger-measurement-technical-guidelines-july-2013.pdf

Beer T, Potterton P and Dickson A (2003). *Appropriateness of 350 million litre biofuels target*, Report to the Australian Government Department of Industry Tourism and Resources. Downloaded 21/10/2013 from http://www.bitre.gov.au/publications/2003/files/cr_001.pdf

DCCEE (2010) *Australian National Greenhouse Accounts, National Inventory Report* 2010, Volume 1. Department of Climate Change and Energy Efficiency, Canberra.

Dixon T F, Hobson P A, Joyce J A, Pohl J H, Stanmore B R and Spero C (1998). *Electricity cogeneration and greenhouse gas abatement in the sugar industry*. Report produced by the Queensland Biomass Energy Group. SRI internal report.

Edye L (2005). *Submission to the Biofuels Taskforce; The findings of the December 2003 CSIRO/ABARE/BTRE desktop study into the appropriateness of a 350-million litre biofuels target*. SRI internal report (no longer available on the internet).

GHG Protocol (2006). *Allocation of GHG Emissions from a Combined Heat and Power (CHP) Plant - Guide to calculation worksheets*. Downloaded 08/12/2013 from, http://www.ghgprotocol.org/files/ghgp/tools/CHP_guidance_v1.0.pdf

Hunt G (2010) The Coalition's Direct Action Plan. Downloaded 08/12/2013 from, http://www.greghunt.com.au/Portals/0/PDF/TheCoalitionsDirectActionPlanPolicy2010.pdf

Hobson PA, Renouf MA (2013a) *Development of a tool for rapid life cycle assessment of sugar and associated energy products* Proc Aust Soc Sugar Cane Technol Vol 35

Hobson PA, Renouf MA (2013b) *Development of tools for rapid and consistent life cycle assessment of sugarcane energy products*. Paper delivered at 14th Bioenergy Australia Conference, Hunter Valley, November.

Hoefnagels R, Smeets E, Faaij A (2010) *Greenhouse gas footprints of different biofuel production systems*. Renew Sustain Energy Rev 14(7):1661–1694.

International Standards Organisation (2006) *Greenhouse gas management and related activities*. ISO 14064:2006. International Organization for Standardization, Geneva, Switzerland.

Luo L, van der Voet E, Huppes G (2009) *Life cycle assessment and life cycle costing of bioethanol from sugarcane in Brazil*. Renew Sustain Energy Rev 13(6–7):1613–1619.

Milford BJ, Pfeffer J (2002) *Canegrower survey*. CANEGROWERS, Brisbane (electronic format).

Nguyen TLT, Gheewala SH (2008) *Life cycle assessment of fuel ethanol from cane molasses in Thailand*. Int J Life Cycle Assess 13(4):301–311.

Ometto AR, Hauschild MZ, Roma WNL (2009) *Lifecycle assessment of fuel ethanol from sugarcane in Brazil*. Int J Life Cycle Assess 14(3):236–247.

Ramjeawon T (2004) *Life cycle assessment of cane-sugar on the island of Mauritius*. Int J Life Cycle Assess 9 (4), 254-260.

Rathore A (2013) *Bioenergy under the Renewable Energy Target and the Carbon Farming Initiative*. Paper delivered at 14th Bioenergy Australia Conference, Hunter Valley, November.

Renouf MA (2006) *LCA of Queensland cane sugar—lessons for the application of LCA to cropping systems in Australia*. 5th Australian Conference on Life Cycle Assessment. Australian Life Cycle Assessment Society, Melbourne.

Renouf M A, Pagan R J and Wegener M K (2011) *Life cycle assessment of Australian sugarcane products with a focus on cane processing*. Int J Life Cycle Assess, 16:125–137.

Renouf M A, Wegener M K and Pagan R J (2010) *Life cycle assessment of Australian sugarcane production with a focus on sugarcane growing*. Int J Life Cycle Assess, 15:927–937

Renouf M A and Allsopp P (2013) *Development of a streamlined life cycle assessment (LCA) tool for assessing the environmental benefits of progressive sugarcane growing*. Final Report – SRDC Project UQ045.

Silalertruksa T, Gheewala SH (2009) *Environmental sustainability assessment of bio-ethanol production in Thailand*. Energy 34 (11):1933–1946.

Standards Australia (1998) *Environmental management - life cycle assessment*. AS/NZS ISO 14042. Standards Australia.

Tate and Lyle (2010) Tate and Lyle Annual Report 2010. http://annualreports.tateandlyle.com/2010/ara/servicepages/downloads/files/entire_tal_ara10.pdf (referenced December 2013).

Thorburn P J, Biggs J S, Collins K, Probert M E (2010) *Using the APSIM model to estimate nitrous oxide emissions from diverse Australian sugarcane production systems*. Agriculture, Ecosystems and Environment **136**, 343-350.

Wang M, Wu M, Huo H et al (2008) *Life-cycle energy use and greenhouse gas emission implications of Brazilian sugarcane ethanol simulated with the GREET model*. Int Sugar J 110 (1317):527–545.