

Peer review of URS GHG lifecycle analysis of bioethanol from whey

Final report to Energy Efficiency and Conservation Authority

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E4tech has been commissioned to peer review a GHG lifecycle assessment of bioethanol produced from whey

- The Energy Efficiency and Conservation Authority (EECA) has commissioned E4tech, a European sustainable energy consultancy, to carry out a peer review of work undertaken by URS New Zealand to assess the lifecycle GHG emissions arising from the production of bioethanol from whey. This report presents the findings of that peer review. Brief highlights of E4tech's experience in the area of bioenergy GHG lifecycle assessment are provided in Annex 1.
- Whey is a by-product of cheese or casein manufacturing. It is generally re-processed into other products since it cannot be disposed of directly without causing negative environmental impacts. 'Acid whey' can be fermented to produce bioethanol which, when purified, is suitable for use as a transport fuel. Fonterra, the New Zealand dairy co-operative, currently produces bioethanol at its plants in Edgecumbe, Reporoa and Tirau in New Zealand.
- The whey to bioethanol fuel chain has not been studied in as much detail as other biofuel production routes. As a result there are fewer literature sources available to cross check the analysis by Fonterra and URS. E4tech is only aware of one other LCA study that has looked at this production route:
 - Zah, R., Boni, H., Gauch, M., Hischer, R., Lehmann, M. & Wager, P. (2007). *Life cycle assessment of energy products – Environmental impact assessment of biofuels*. EMPA.

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The boundaries of analysis employed by URS were appropriate and are consistent with international best practice

- The boundaries of analysis defined by URS captured all sources of GHG emission from the point at which the whey enters the bioethanol production process, to the point at which the bioethanol is delivered to the fuel depot where it is blended.
- It is appropriate (and consistent with international best practice) to treat the GHG emissions caused by upstream processes (i.e. those occurring before the whey is delivered to the bioethanol production process) as being outside the system boundaries. This is because these GHG emissions would occur regardless of whether or not the whey was converted to bioethanol – and therefore cannot reasonably be attributed to the bioethanol itself. As discussed in a separate peer review carried out for EECA, the UK's Renewable Fuel Agency is currently conducting research into whether there are other effects outside these normal system boundaries that also need to be taken into account e.g. emissions that would arise from diverting whey from an existing alternative use. EECA should monitor these activities and update their methodology if appropriate.
- Setting the end point of the analysis as the point at which the bioethanol is delivered to the fuel depot is consistent with the UK RTFO approach. This boundary was created for practical purposes (because companies report on a fuel's carbon intensity when it reaches this point). It is possible that some GHG emissions will be incurred in the blending itself, however, a brief analysis suggests these would be less than 1 percent of total fuel chain emissions (less than 0.1 g CO₂e / MJ) and are therefore negligible.

The exclusion of small and uncertain sources of GHG emissions is consistent with international best practice

- URS have not included in their analysis the GHG emissions from certain inputs that would have only contributed a very small proportion of total fuel chain emissions (less than 1%) and for which inadequate data is available – for example, emissions of the HFCs & PFCs, and emissions caused by the use of chemicals in the process.
- Both the approach used to identifying the sources of emissions that should be excluded (e.g. referencing other studies or estimating the potential contribution of an input using a very conservative emissions factor) and the sources of emissions that have been excluded (e.g. small quantities of process chemicals) are consistent with international best practice (e.g. the UK RTFO, the EU's Renewable Energy Directive methodology).

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Sourcing data from Fonterra reflects actual plant operation, but its representativeness of industry practice needs validating

- URS have used data provided by Fonterra for their Reporoa bioethanol plant. URS correctly note that the data has some weaknesses since it is only from one bioethanol plant, sourced over one calendar year. However, it is important to emphasise that the benefits of using this data outweigh these negatives, for example:
 - The data is based on actual plant operation, rather than on plant design specifications which is often the case for other lifecycle analysis.
 - Because the data has been drawn from one plant it is internally consistent. Often data has to be sourced from several different references for lifecycle analysis. This can sometimes create inconsistencies which affect the final results.
- Because of the restricted scope of the data, care should be taken to ensure the results of this study are used appropriately. For example, it would be inappropriate to cite the results as being representative of all NZ whey bioethanol production without some investigation of practice at the other Fonterra plants. Particularly important would be checking data related to steam generation – including both the amount of energy required for steam and the fuel used to provide that energy (e.g. is coal used at any other plants).

Natural gas requirements for process heat at Reporoa appear high compared with other bioethanol production routes

- The data supplied by Fonterra was briefly reviewed against similar data sourced from other references. The analysis focused on the two main contributors to fuel chain GHG emissions: natural gas use for steam, and electricity. Unfortunately, there is no data available in the literature on the energy requirements of the whey to bioethanol process. The EMPA study mentioned earlier is based on data sourced from the 'ecoinvent' database which is not publicly available. Therefore, energy requirements for bioethanol produced from other feedstocks has been shown (see next page) to provide a comparison.
- As the results on the next page illustrate, at 1 GJ / tonne bioethanol the electricity consumption at the Reporoa plant is very similar to that of other bioethanol fuel chains.
- However, the natural gas consumption (28 GJ / tonne bioethanol) is significantly higher – more than twice the amount of energy required by most other fuel chains. It is possible the higher heat requirements are due to the characteristics of the whey bioethanol production process – e.g. the concentration of ethanol after fermentation may be much lower than in other processes (typically 4-6%). This would mean distillation energy requirements (i.e. in the production of standard ethyl alcohol - SEA) would be substantially higher. If post-fermentation ethanol concentrations are not substantially lower than other processes, it would be worth investigating the process further to check where the measured steam is being used – it may be that some is being used in other upstream processes that would fall outside the system boundaries.

Comparison of processing energy requirements for bioethanol production from different feedstocks

Feedstock	Process heat (GJ fuel / tonne bioethanol)	Electricity (GJ / tonne bioethanol)	References
Whey	28 (natural gas)	1.0	URS Report
Corn	11 (natural gas) – 14 (coal)	1	EEA (2006). An assessment of the Potential for Energy Savings in Dry Mill Ethanol Plants from the Use of Combined Heat and Power.
Molasses	13 (biomass)	1.8	CSIRO (2004). Life-cycle Emissions Analysis of Alternative Fuels for Heavy Vehicles.
Sugar cane	18.75 (coal)	0.5	Woods, J. (2000). Integrating sweet sorghum and sugarcane for bioenergy: modelling the potential for electricity and ethanol production in SE Zimbabwe. PhD Thesis, King's College London.
Wheat	12.6 (natural gas) Only 6-7.5 GJ used for bioethanol production, remainder for drying by-products	1.4 – 1.6	Industry sources

Note: a detailed breakdown of data used in the EMPA study of whey to bioethanol is not available publicly.

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Conclusions

- The analysis carried out by URS is of a good standard. The boundaries used to assess the lifecycle GHG emissions of Fonterra's bioethanol production from whey are appropriate and consistent with international best practice.
- The data provided by Fonterra and URS appears sound. The natural gas consumption appears to be much higher than in production of bioethanol from other feedstocks. However, the original source of this data is reputable and there is probably an explanation linked to the characteristics of the whey to bioethanol plant – e.g. ethanol concentration following fermentation.

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E4tech has a range of experience in developing & applying methodologies for assessing lifecycle GHG emissions

- ***Development of the Carbon Reporting Scheme for the UK's Renewable Transport Fuel Obligation (RTFO)***. Development of the world-first scheme for reporting the lifecycle greenhouse gas emissions of biofuels supplied under the UK's RTFO. The project involved:
 - Adaptation of lifecycle analysis methodologies to allow for practical reporting by industry, while maintaining accuracy and comparability between fuel chains.
 - Development of a comprehensive technical guidance that simplifies the reporting requirements for industry. This includes “default values” for 140 unique fuel chains to facilitate reporting when information about a biofuel is limited.
 - Extensive stakeholder consultation on all aspects of the scheme, from methodological issues through to detailed default value setting. This included outreach to governments exploring similar schemes, e.g. the European Commission, the Netherlands, Germany and California.
- The scheme has now been in operation for over 12 months and has successfully been used to report lifecycle carbon intensity information for over 1.3 billion litres of biofuel. The scheme has been drawn on extensively for the development of similar schemes by governments in the USA and Europe. E4tech now provides the Renewable Fuels Agency (RFA) with development support for the scheme. For more information: <http://www.renewablefuelsagency.org>.

E4tech has a range of experience in developing & applying methodologies for assessing lifecycle GHG emissions

- **Methodology development support for PAS 2050.** E4tech provided support to the Carbon Trust in the role as Technical Authors of PAS 2050, a private standard specifying a methodology for assessing the lifecycle GHG emissions of goods and services. E4tech was engaged to facilitate discussion between LCA academics and practitioners on key methodological issues, and to synthesize the debate into a practical way forward for PAS 2050.
- **Development of a low carbon fuel standard for China.** E4tech is currently working with the Innovation Centre for Energy and Transportation and China's Development Research Centre (DRC) to promote the introduction of a Low Carbon Fuel Standard for China. E4tech has provided advice on the detailed design of an LCFS for China as well as broader low carbon fuel policy frameworks. E4tech has also provided assistance with the development of a life cycle carbon intensity methodology for use within the LCFS. This has included addressing key methodological issues as well as assistance with applying the methodology to key fuel chains, for example, maize to ethanol, cassava to ethanol and coal to liquids. The project is on-going.
- **Lifecycle GHG assessments of bioenergy chains for investors and project developers.** E4tech has carried out projects for clients who need a comprehensive and independent assessment of the GHG emissions from a bioenergy chain. Examples include an Argentine soy-biodiesel chain (for a large private equity investor), a bioliquid-fuelled power plant (for the project developer), and 2nd generation pyrolysis technologies (for the Carbon Trust's Pyrolysis Challenge).