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The Role of Renewable Diesel in Decarbonising Public Transport

A case study from New Zealand

Image: NZ Herald

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Project description

Introduction - Auckland Transport

- Transport systems are a fundamental part of cities. They provide vital access for people, goods, and services which are the lifeblood of cities

- Auckland Transport (AT) plays an active role in shaping Auckland as a sustainable city in Aotearoa New Zealand

- AT commits to providing low-emission transport choices for Aucklanders.
  - This helps mitigate greenhouse gas (GHG) emissions, improves air quality, and reduces the city's reliance on fossil fuels.

- AT has committed to electrify its bus fleet by 2035
  - During this 12-year transition, AT intends to reduce its GHG emissions.
  - Using renewable diesel for some of their bus fleet is an option.

Goal of this study

- This study was commissioned to give a scientifically robust understanding of the climate impacts of the life cycle of renewable diesel produced globally, shipped to, and used in Aotearoa New Zealand.

- This study aims to:
  - Provide evidence-based advice to support procurement decisions on renewable diesel.
  - Ensure stakeholder buy-in for renewable diesel use in the bus fleet.
  - Inform the public (primarily Aucklanders) about AT’s commitment toward a low emissions economy.

Image: supermarket news

Data and methods

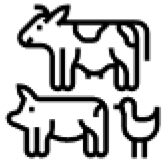
Methodology

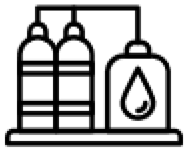
- We used an attributional LCA approach.
- There's limited public data available, given the relative novelty of technology to produce renewable diesel (Xu et al., 2020; 2022).
  - Most of the existing data is based on Neste's renewable diesel production systems (Nikander, 2008; Xu et al., 2022).
- Carbon footprint is the primary environmental indicator as climate change is often deemed to be the most pressing environmental issue.
- Carbon footprint is measured using Global Warming Potential (GWP) (excl. biogenic).
  - Expressed as kilograms of carbon dioxide equivalent (kg CO_2 eq.) per functional unit, as specified in ISO 14067 (ISO, 2018).
  - GWP (excl. biogenic) is more relevant from a climate change perspective, given the carbon sequestered from the atmosphere is re-emitted over a short period.
- This study follows international standards ISO14067:2018 (ISO, 2018) for product carbon footprinting and ISO14044 for Life Cycle Assessment (LCA) (ISO, 2006).

Functional unit and system boundary

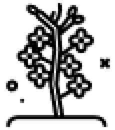
- Focuses on renewable diesel production in Singapore, using six different feedstocks.
- Functional unit: 1 megajoule (MJ) of renewable diesel produced in Singapore, shipped to New Zealand, and used in the AT bus fleet in Auckland.
- System boundary: cradle-to-grave
  - Upstream processes (from cradle-to-gate) covers producing and collecting feedstock and transport to a facility that produces renewable diesel.
  - Core processes (from gate-to-gate) include purifying feedstock and producing renewable diesel via hydro-processing.
  - Downstream processes (from gate-to-grave) cover distribution to New Zealand and use in the AT bus fleet.
- Allocation
  - Economic allocation was applied when necessary.
  - Animal products (such as carcasses, heads, and feet) were treated as wastes from the slaughtering process – hence, upstream impacts were excluded.
  - No allocation was required for UCO, given there are no valuable co-products from the UCO rendering process.


Used cooking oil (UCO)


Animal fat/tallow

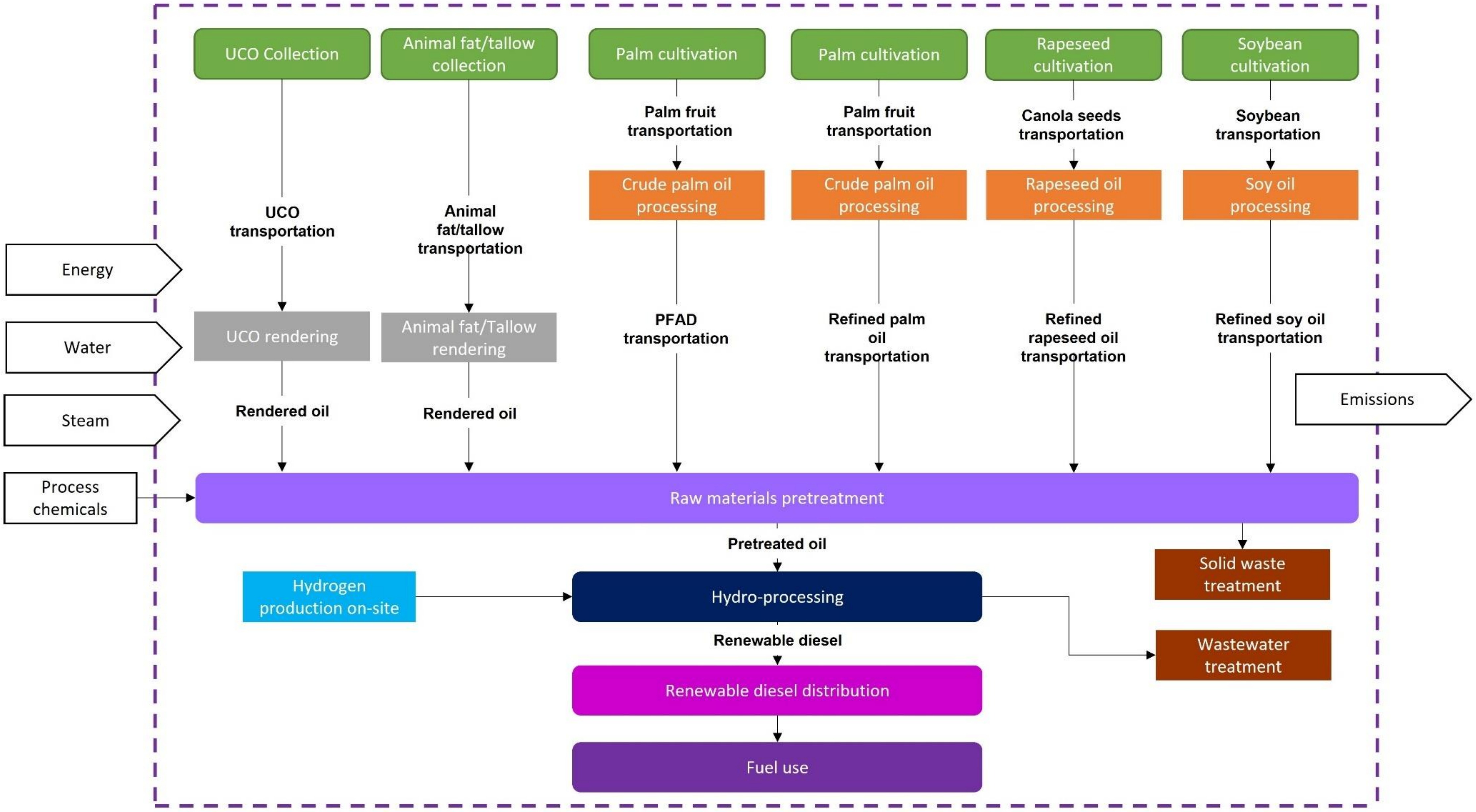

Palm Fatty Acid Distillate (PFAD)


Palm oil


Rapeseed (Canola) oil


Soybean oil

System Boundary

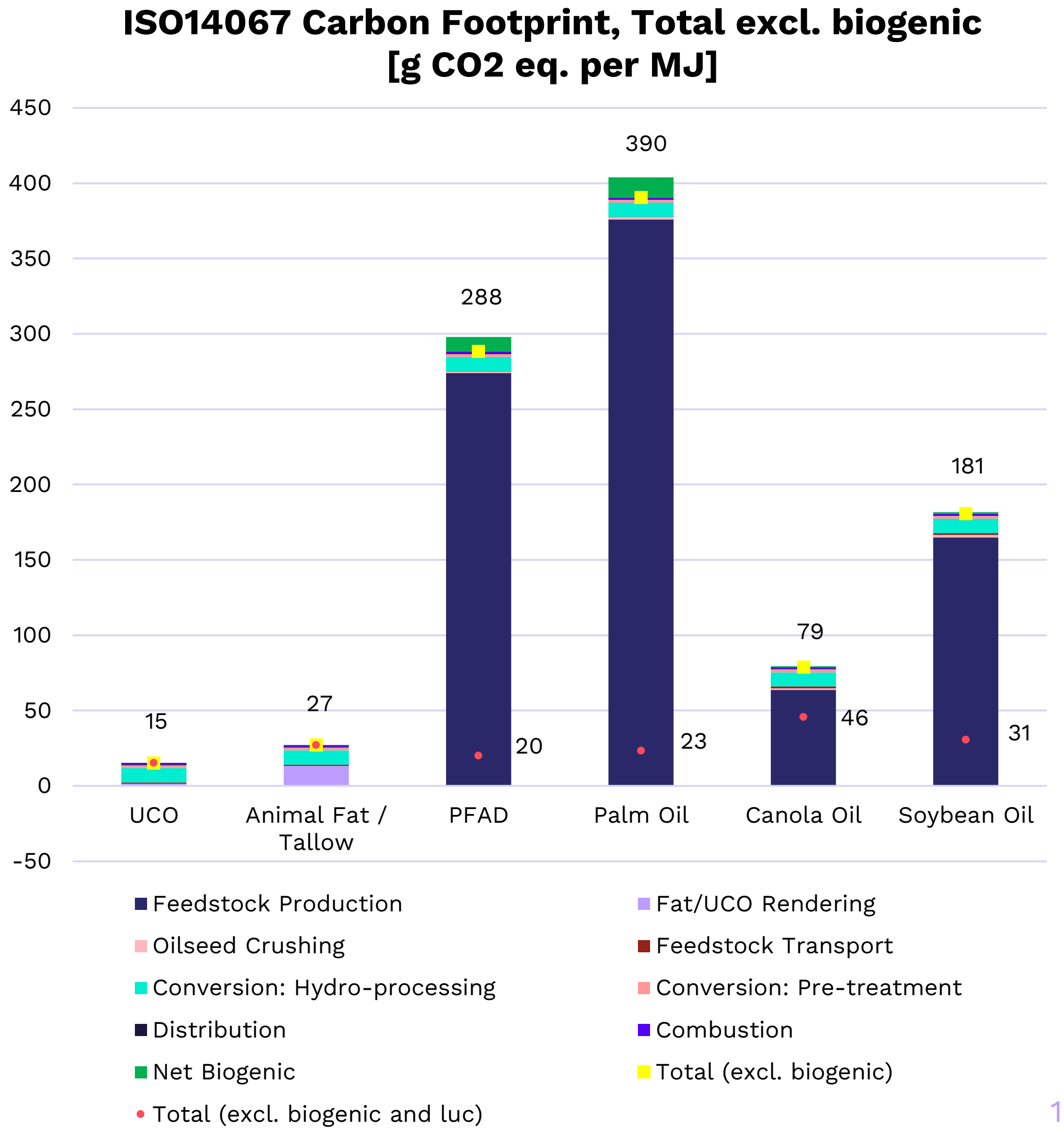


Results

Carbon Footprint of Renewable Diesels

Carbon footprint (CF) – Total (excl. biogenic)

- CF-Total (excl. biogenic) for renewable diesels range between 15.3 and 390 g CO_2 eq. per MJ.
- Palm oil-derived renewable diesel shows the highest CF while UCO-derived renewable diesel shows the least.
- Vegetable oil-derived (including PFAD) renewable diesels show higher impacts compared to UCO and animal fat / tallow.
  - Mainly due to land use change impacts and how different feedstocks are modelled in this study.
  - For example, all vegetable oil derived renewable diesels include upstream impacts which include land use emissions whereas upstream impacts for UCO and animal fat / tallow are zero or negligible.



Carbon footprint – Fossil

- CF-Fossil results for renewable diesels range from 15.3 to 45.8 g CO_2 eq. / MJ.
  - Rapeseed oil-derived renewable diesel shows the highest CF-Fossil results while UCO-derived renewable diesel shows the lowest.
  - This trend is different to the trend observed for CF-Total (excl. biogenic).

Carbon Footprint – Aviation

- CF-Aviation results are negligible compared with CF-Fossil. CF-Aviation results for renewable diesels range from 1.96E-06 to 1.01E-05 g CO_2 eq. / MJ.

Carbon Footprint – Land Use Change

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- CF-Land Use Change impacts are modelled based on the work commissioned by the European Commission (ECOFYS, 2015).
  - They include both direct and indirect land use change emissions.
  - Palm oil-derived renewal diesel showed the highest emissions while canola oil-derived renewable diesel showed the lowest
  - These results clearly reflect the different agricultural land required for producing feedstock, mainly in terms of expanding agricultural activities, including deforestation

	Feedstock Production	Fat/UCO Rendering	Oilseed Crushing	Feedstock Transport	Conversion: Pre-treatment	Conversion: Hydro-processing	Diesel Distribution	Diesel Combustion	Total
UCO	0.000	0.001	0.000	0.005	0.000	0.000	0.001	0.000	**0.006**
Animal Fat/Tallow	0.000	0.003	0.000	0.010	0.000	0.000	0.001	0.000	**0.014**
PFAD	268	0.000	0.000	0.003	0.000	0.000	0.001	0.000	**268**
Palm Oil	367	0.000	0.000	0.004	0.000	0.000	0.001	0.000	**367**
Rapeseed Oil	33	0.000	0.000	0.001	0.000	0.000	0.001	0.000	**33**
Soybean Oil	150	0.000	0.000	0.001	0.000	0.000	0.001	0.000	**150**

Fossil vs Renewable Diesels

- → CF-Total (excl. biogenic) of fossil diesel is 86 g CO_2 eq./MJ (Sphera, 2022).
- → At least **×1.08** higher than the emissions of renewable diesels, except for soybean-, PFAD-, and palm oil-derived renewable diesels.
- → Soybean-, PFAD-, and palm oil-derived renewable diesels are respectively 2.12, 3.37, and 4.56 times worse than fossil diesel.
- → Overall, shifting to renewable diesel would emit at least 7.83% less greenhouse gases, except for soybean-, PFAD-, and palm oil-derived renewable diesels.

Feedstock		Carbon footprint (in g CO2 eq./MJ)	Reduction potential
	Used Cooking Oil (UCO)	15	82%
	Animal Fat/tallow	27	68%
	Rapeseed Oil/Canola	79	8%
	Fossil diesel	86	-
	Soybean oil	181	-112%
	Palm Fatty Acid Distillate (PFAD)	289	-237%
	Palm oil	390	-356%

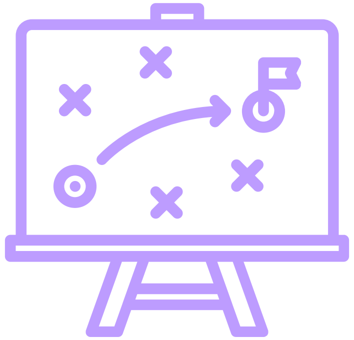
Conclusions and recommendations

Conclusions and recommendations

- This study shows that producing and using renewable diesel in the AT bus fleet has some potential to mitigate GHG emissions in Aotearoa New Zealand.
- Renewable diesels derived from wastes (such as UCO and animal fats) have the greatest potential compared to renewable diesels derived from virgin vegetable oils.
  - The CF-Total (excl. biogenic) results for renewable diesels produced in Singapore range from 15 (UCO-derived) to 390 g CO_2 eq. / MJ (palm oil-derived).
  - Rapeseed oil shows better potential, among renewable diesels derived from virgin vegetable oils.
- Opportunities for reducing the overall GHG emissions of renewable diesels include:
  - Mitigating emissions from land use change through cultivating oil crop;
  - Developing new or improving existing technologies to produce hydrogen for hydro-processing; and
  - Identifying appropriate feedstock suppliers internationally.

Conclusions and recommendations (contd.)

- We recommend future work to improve the accuracy of the results of the study:
  - Source primary and latest data for producing renewable diesel systems – primarily for Neste in Singapore.
  - Perform scenario analysis to understand the effects of different modelling choices such as allocation, origins of feedstock, LCI and datasets.
  - Undertake further analysis to better understand the direct and indirect land use change impacts related to increased demand for renewable diesel in future.
    - A Consequential LCA is an option (Ekvall, et al., 2016).



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