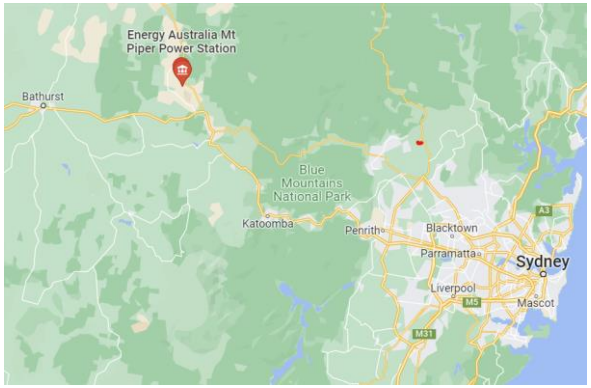
Life Cycle Assessment of Biomass Co-firing in a Coal-fired Power Plant

Background

Background

Motivation for project

- Work commissioned by DPI NSW
- With funding from NSW Climate Change Fund
- Primary objective: to compare different options for biomass co-firing in NSW



Biomass feedstocks

Energy crops

- any biomass grown for the specific purpose of producing bioenergy
- Often on land that is not suitable for growing food crops
- Crops are coppiced

Forestry residues

- the excess parts of the biomass left behind after forestry products have been harvested.
- branches, leaves and roots
- Common practise to burn on site

Urban wood waste

- green waste, construction wood waste.
- tends to be most suitable for combustion since it is dry

Biomass processing

Chipped biomass

- Biomass is typically chipped on site
- Chips are dried, either with combustion of fossil fuels, combustion of some of the biomass itself, or in some cases waste heat

Wood flour

- Chips are ground to fine powder
- Can be combusted as is, if no transport required
- Otherwise, transformed to pellets

Pellets

- Powder is compressed into pellets (pelletisation)
- Ideal moisture content 8%

Goal and scope

Questions

- What are the benefits of cofiring?
- How do they vary with feedstock?
- How do they vary with processing choices?

Impact categories:

– Climate change	IPCC 2013
– Particulate matter	Impact World+ 2011
– Fossil fuel depletion	CML-IA 2016
– Water scarcity	Pfister et al. 2009
– Land use, species loss	ReCiPe (H) 2016

Biomass feedstocks modelled:

1. Energy crops
   - River red gum (Eucalyptus camaldulensis)
   - Sugar gum (Eucalyptus cladocalyx)
   - Orange wattle (Acacia saligna)
2. Forestry residues
   - Pinus radiata
3. Urban wood waste

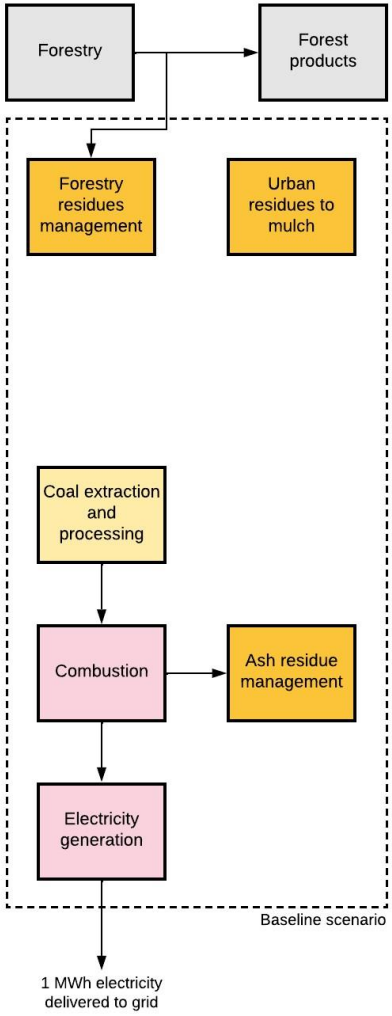
Goal and scope

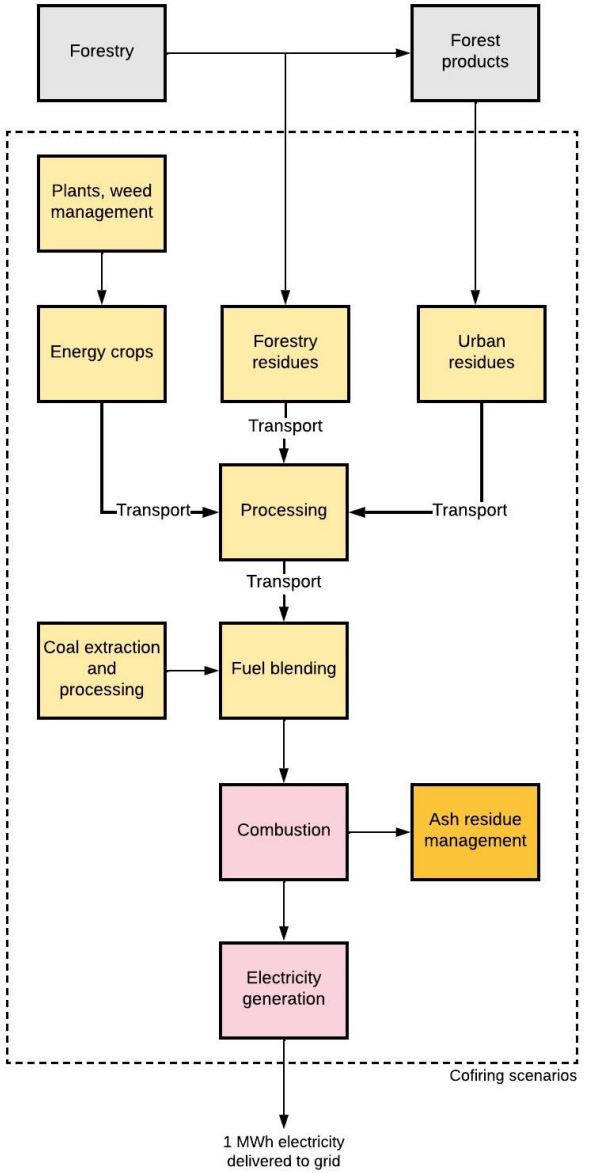
System boundary

- Functional unit:
  - 1 MWh of electricity

- Alternative fates:
  - **Urban residues** – mulched (10% carbon retained, resulting in carbon sequestration effect)
  - **Forestry residues** – 60% burnt (carbon emissions biogenic), 40% left in forest (assumed no net soil carbon change)

- Data sources
  - Literature
  - CSIRO biomass database
  - Clean Energy Regulator
  - NPI
  - Coal mine annual reports
  - AusLCI database





Modelling choices and assumptions

Modelling choices

- A biomass fraction of 5% by mass.
- Drying by combustion of biomass, processing into pellets
- The production of energy crops occurs on land previously used for high-intensity grazing

Assumptions

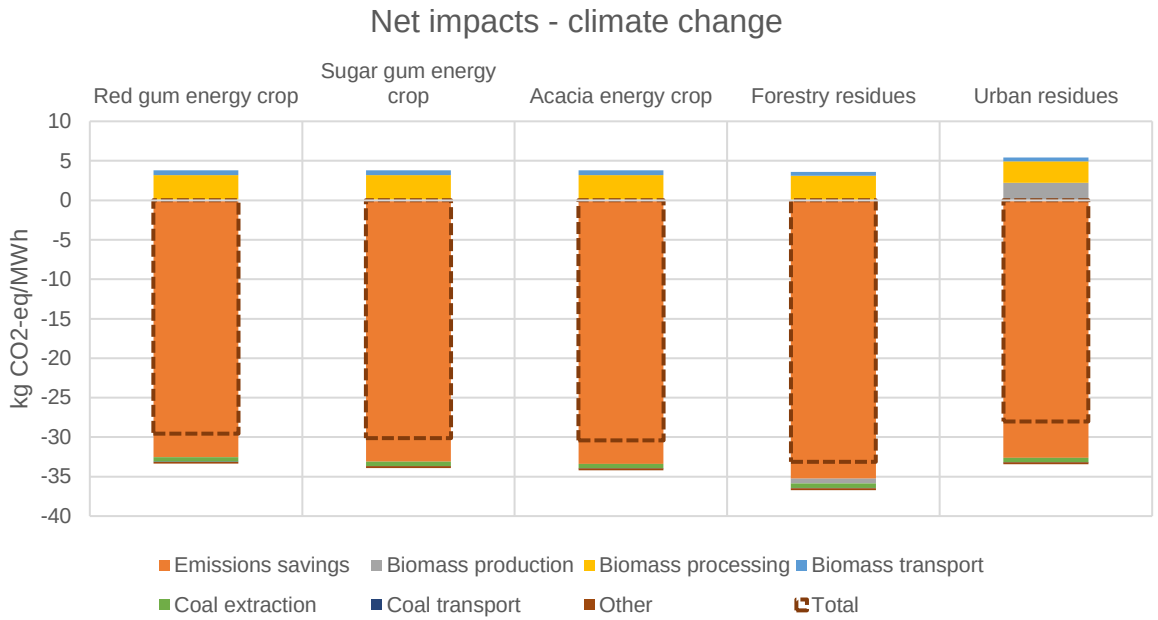
- Carbon dioxide emitted during combustion or breakdown of biomass is biogenic.
- PM emissions in ‘low population’ areas
- The combustion of biomass is assumed to emit no sulphur oxides.
- remaining emissions during combustion of the coal-biomass mix are approximately equal to the 100% coal baseline.
- biomass feedstock burns with the same energy efficiency as coal - 37%

Results

Climate change and PM

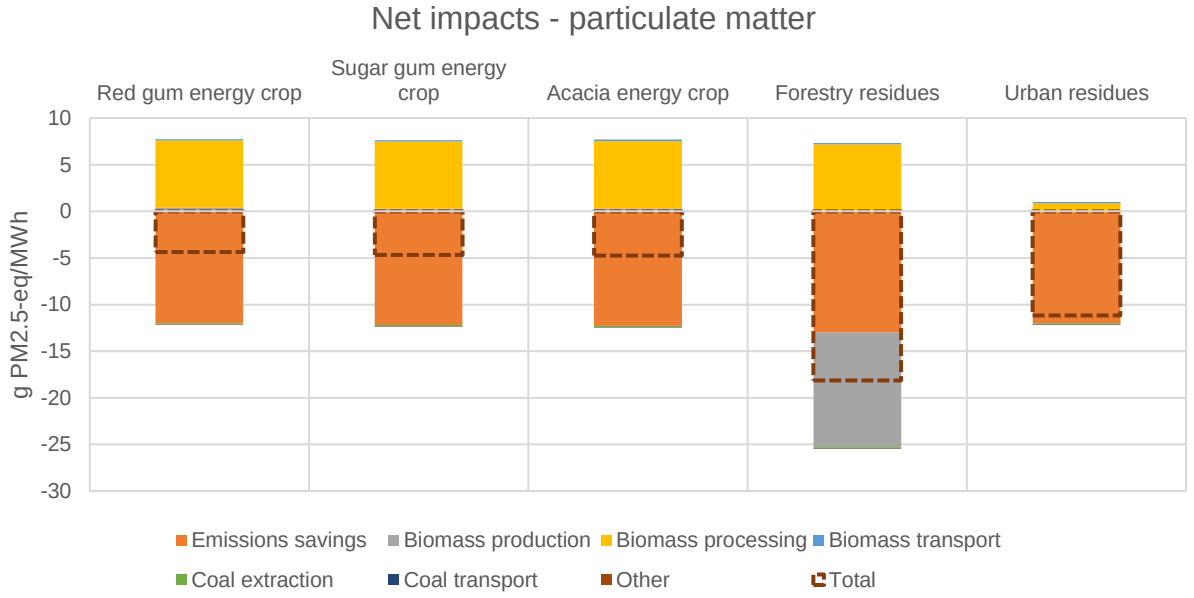
Climate change

- 5% biomass leads to **3.4% reduction** in climate change impacts (limited partly due to processing, mostly energy content)
- majority of benefits due to emissions savings
- **forestry residues** biomass option shows slightly larger benefits (energy content)
- **urban residues** slightly higher impact during the production phase (alternative fate)



Particulate matter

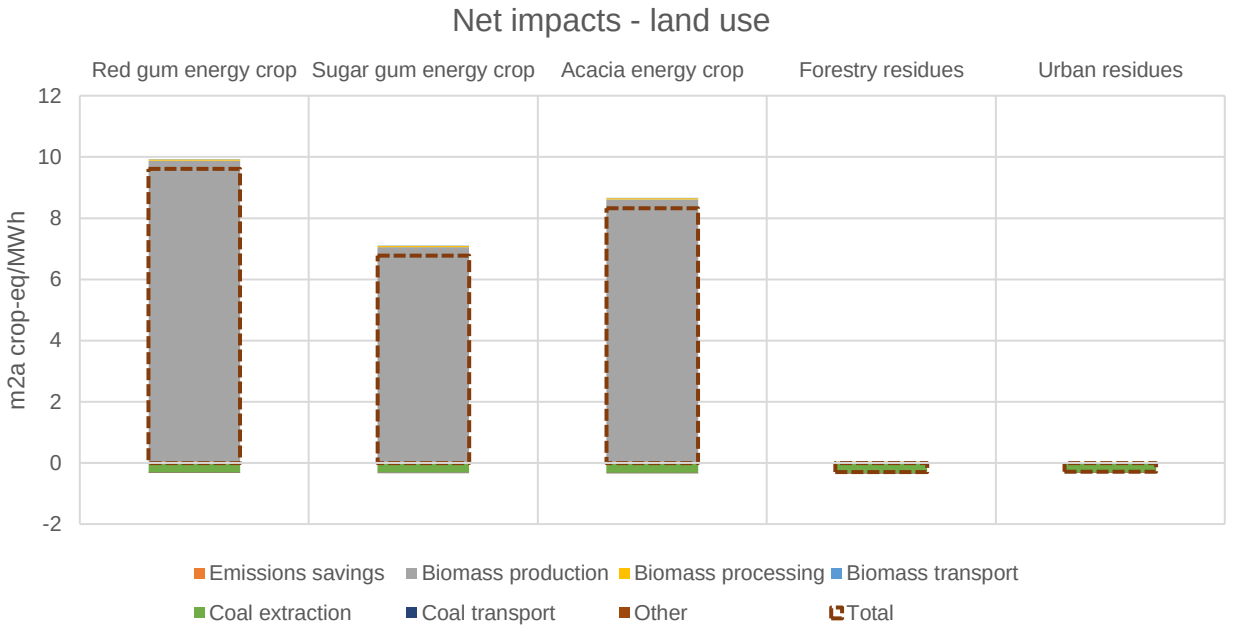
- 5% biomass leads to **1-5% reduction** in PM impacts
- processing impacts are outweighed by the emissions savings
- **urban residues** result in larger savings (already dried, any previous drying not allocated to the residues).
- **forestry residues** result in the largest net benefit (avoided 60% burning).



Land and water

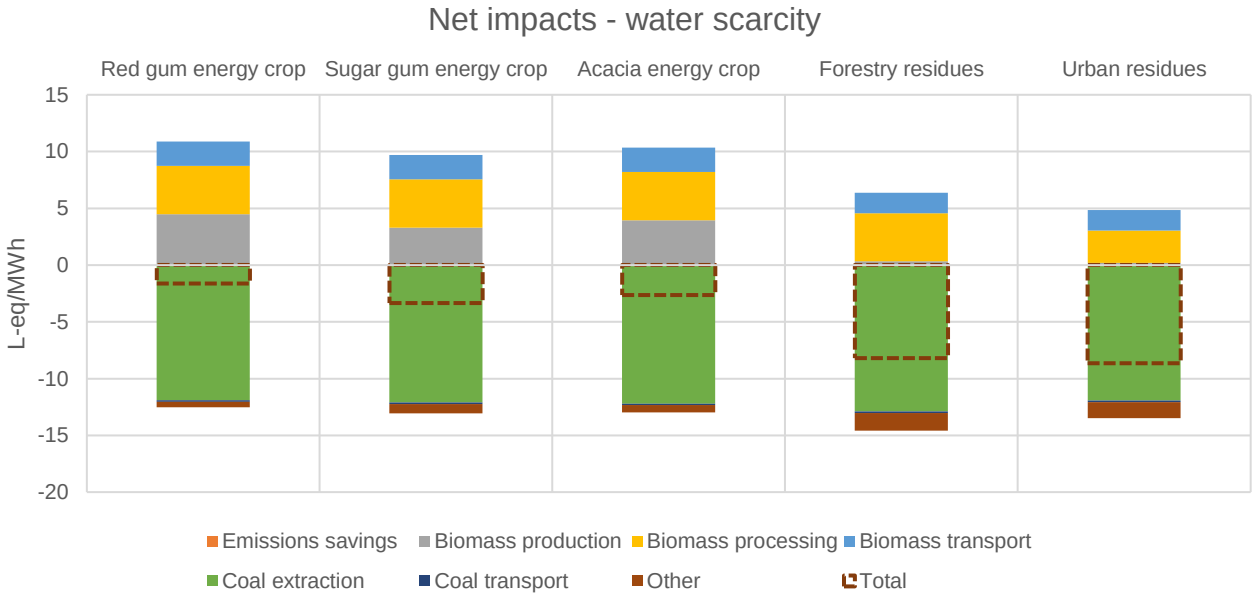
Land use

- energy crops all show an overall increase in land use impacts 80-110% (crop growing)
- residues require no land (i.e. no land use impacts have been allocated to the residues), their use results in a small decrease in land total land use, 3-4%
- Haven't accounted for potential land displacement



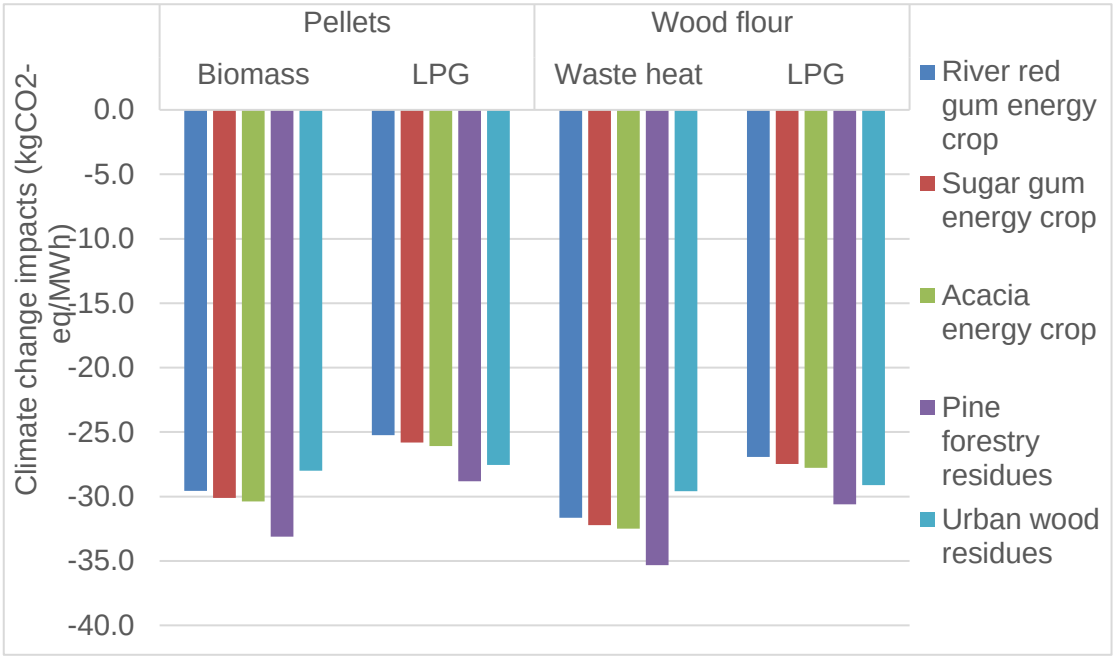
Water

- some variation between feedstock options, though overall savings are small, 0.1-0.7%

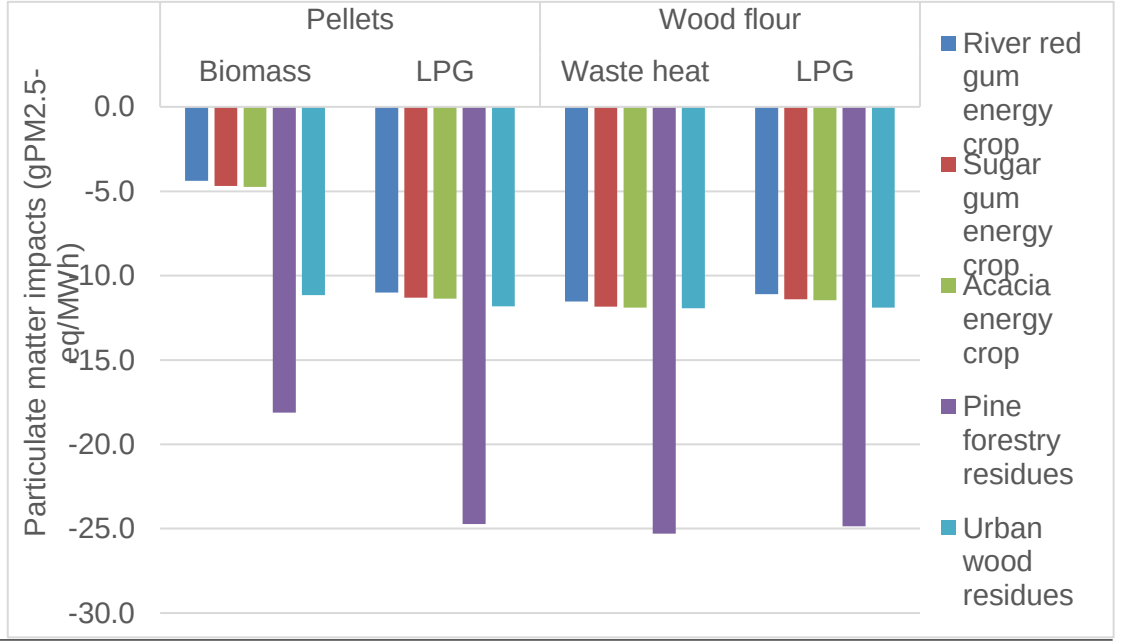


Effect of processing choice

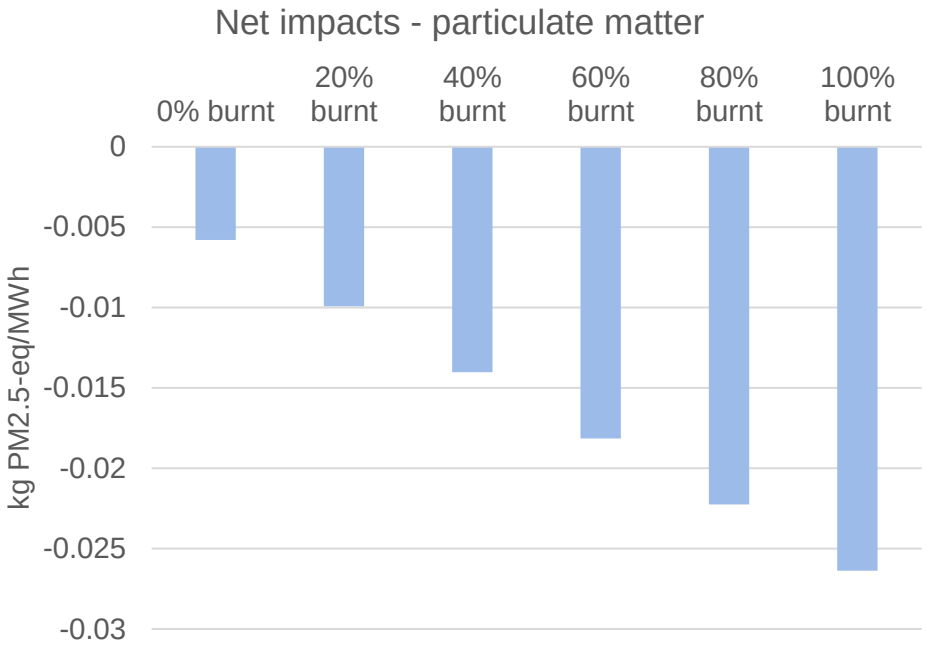
- Drying fuel has an effect
- For climate change, the largest benefits occur with wood flour processing and waste heat drying



- For particulate matter, pelletisation with biomass drying results in the least savings overall
- Forestry residues result in the largest savings across all processing options, (prevention of burning)

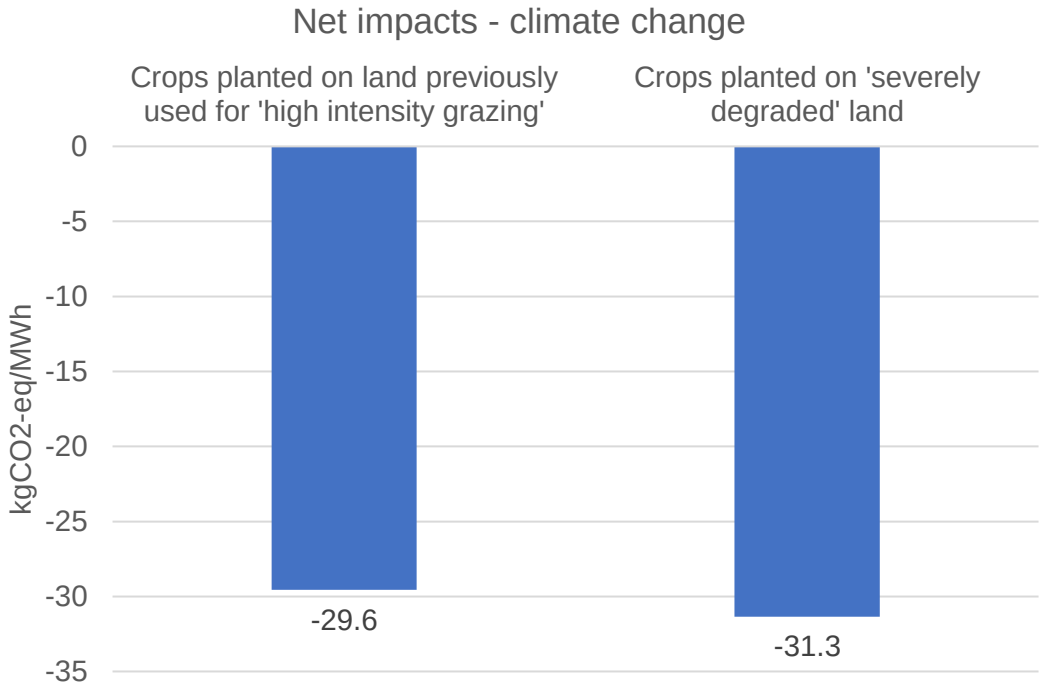


Effect of other factors



Forestry residues alternative fate

—Climate change indicator not affected
—If fraction reduces still benefits overall



Land transformation

—The more degraded the land, the greater the potential carbon sequestration from energy crops
—Stock change factor 0.7
—6% increase in benefits

Conclusions

Results summary

- all biomass feedstock options result in overall benefits for most categories
- Little difference between energy crops
- forestry residues tend to lead to the greatest benefits
- Processing with waste heat into wood flour results in greatest savings

Further thoughts

- Other barriers beyond the environmental
  - Supply
  - Logistics
  - Public perceptions

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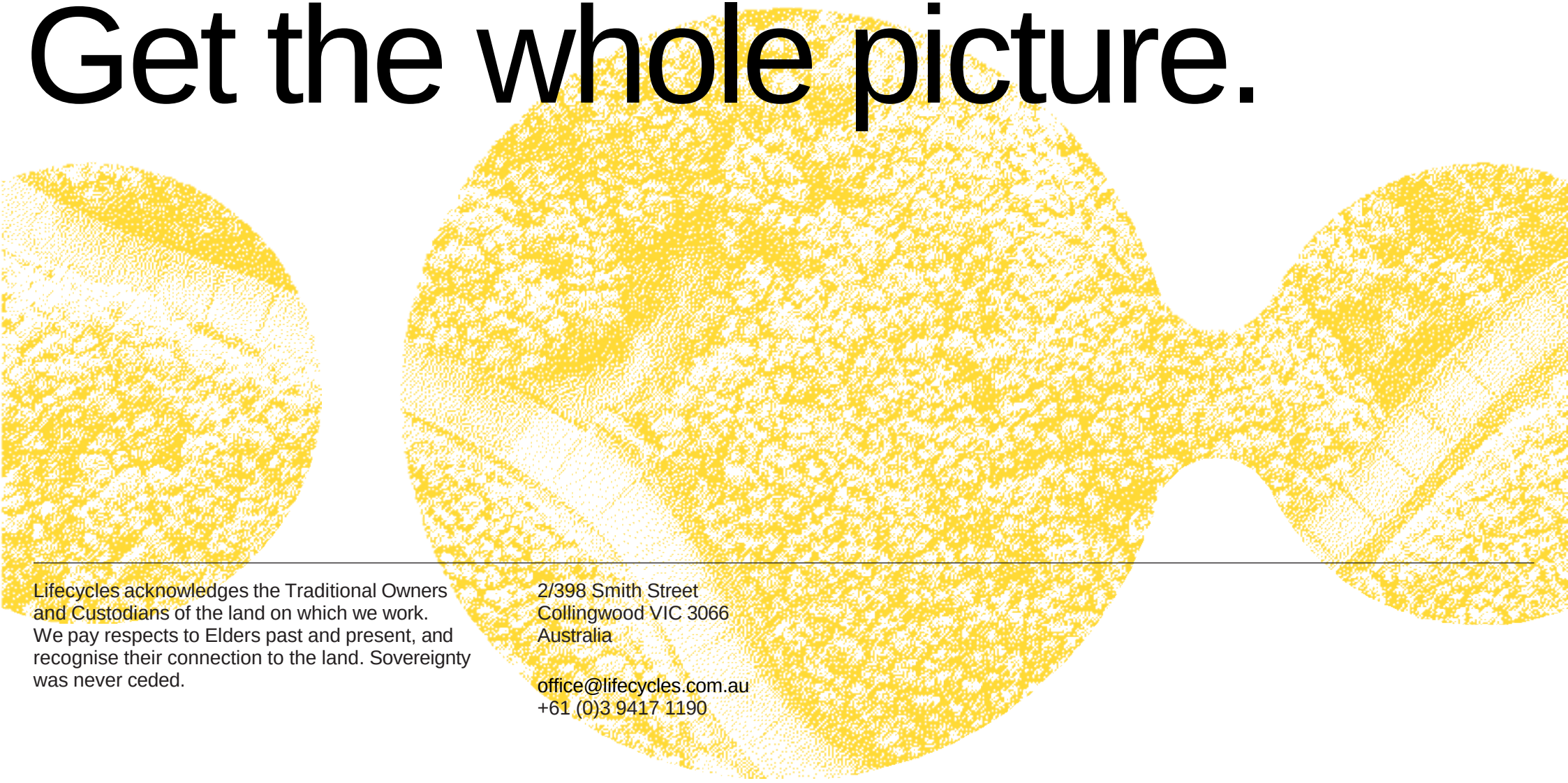

Lifecycles acknowledges the Traditional Owners and Custodians of the land on which we work. We pay respects to Elders past and present, and recognise their connection to the land. Sovereignty was never ceded.

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