Forest residues for renewable carbon in the Australian bioeconomy

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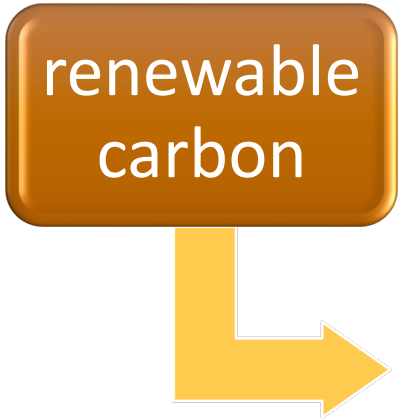
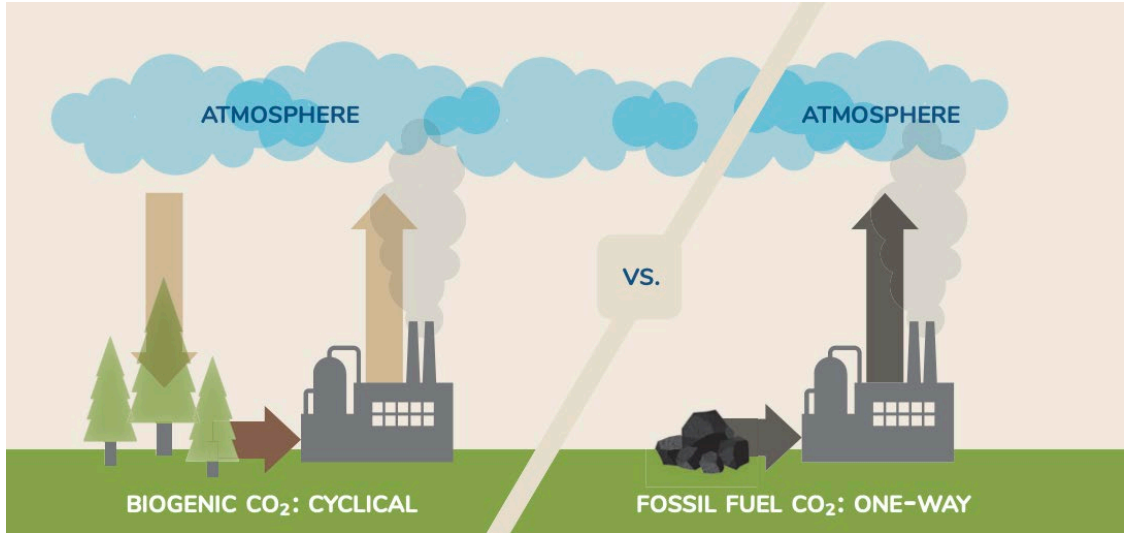
- 'non-merchantable tree fractions leftover from tree harvesting or thinning operations. Also 'primary feedstocks', 'harvest residues', 'logging residues'



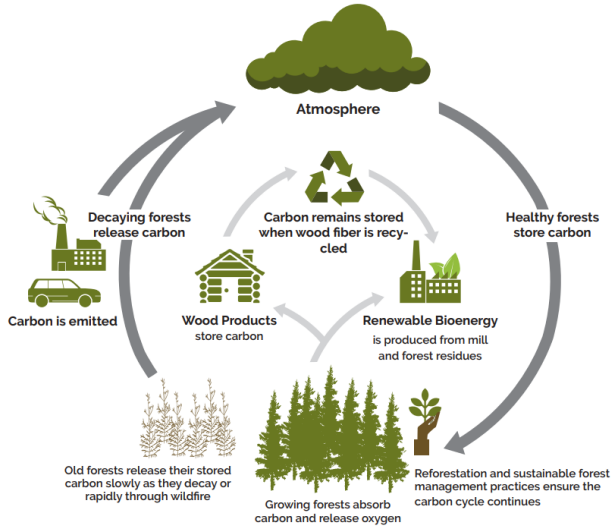
- Sources of carbon that mitigate or substitute fossil carbon eg fossil fuels

- 'use of renewable, biological resources to produce food, energy, materials, services for a sustainable economy'

Renewable carbon v fossil carbon



Source: National Council for Air and Stream Improvement [NCASI] 2013



Source: Ministry of Natural Resources and Forestry (Canada) 2022

- **Timeframe** is key difference, also net GHG emissions contributions
- Burning fossil fuel for energy contributes carbon locked up for millions of years - bioenergy returns more recently absorbed carbon
- **Biogenic carbon cycle** - combustion of renewable biomass a **continuous carbon exchange** between biosphere and atmosphere
- Substituting fossil carbon with renewable carbon (eg sustainably managed forests, **can** lead to net emission reductions

Renewable carbon in a sustainable bioeconomy

- **forest residues** are a **renewable carbon carrier** and can contribute to a **forest-based bioeconomy**
- this shift from a linear, **take-make-use-dispose model** to a more **circular model** forms the foundation of a circular economy
- circular model promotes **re-use, recycling** to reduce waste and emissions
- **‘cascading use of wood’** principle means forest bioenergy is not the primary product but value-adding in existing forestry
- other than bioenergy - products include pulp and paper products, wood-based panels, biochemicals, packaging, bioplastics

Source: European Parliament 2015

Forest residues are under-utilised in Australia

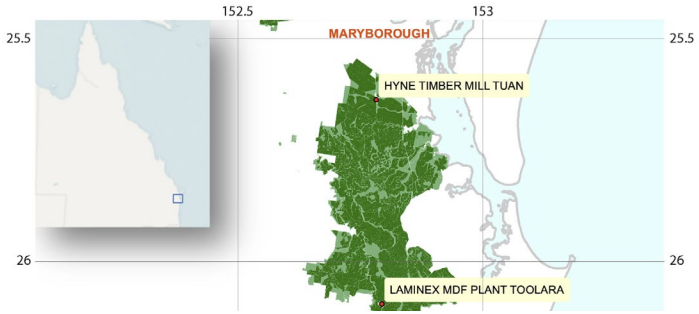
- Australia has almost **1.7 million hectares of commercial plantations**
- **large volumes of forest residues remain behind** after harvesting and thinning operations in commercial operations
- an estimated **6.5 million green tonnes of forest residues** available annually, about half of which comes from softwood plantations
- **native forests are also a biomass source** - when they are thinned for fire mitigation purposes, cleared for alternative uses like agriculture, or are burned in a bushfire
- **mill residues are estimated at 4 million tonnes** annually

Forest residues for renewable carbon in the Australian bioeconomy

- What is the greenhouse gas mitigation potential of replacing fossil fuels with bioenergy generated from plantation forest residues?
- What are the costs and barriers along the forest biomass supply chain in Australia relative to the EU?
- How can forest biomass be delivered to the Australian bioeconomy in the most efficient way?

Greenhouse gas mitigation potential of replacing fossil fuels with bioenergy generated from forest residues

- Case study site – southern pine plantation
- FullCAM - estimate carbon content
- Energy conversion factors - estimate carbon offsets in three scenarios:



Scenario	Bioenergy Product Type	Fossil Fuel Substitution	Residue Alternative	Forest Treatment	% Utilization		
					Stem	Branch	Bark
1	CHP	Coal-fired electricity	1	Thin	5	95	5
				Final harvest			
			2	Thin	95	95	95
				Final harvest	5		5
2	Pellets	Natural gas	1	Thin	5	95	5
				Final harvest			
			2	Thin	95	95	95
				Final harvest	5		5
3	Renewable diesel	Diesel	1	Thin	5	95	5
				Final harvest			
			2	Thin	95	95	95
				Final harvest	5		5

Greenhouse gas mitigation potential of forest residues

- **27 tonnes carbon** per hectare available (full rotation)*
- Branches had the largest volume, bark comprised 2% of total volume

- **Scenario 1 - CHP replacing coal-fired electricity** - highest GHG mitigation potential (**4.61 t CO2-e ha^{-1} year^{-1}**)
- **Scenario 3 - Renewable diesel** could offset **1.38 t CO2-e ha^{-1} year^{-1}**
- **Scenario 2 - wood pellets** could offset **1.24 t CO2-e ha^{-1} year^{-1}** (50 km)

Residue Alternative	Forest Treatment	Stems (tC ha^{-1})	Branches (tC ha^{-1})	Bark (tC ha^{-1})	Total (tC ha^{-1})
1	Thinning	0.84	4.79	0.12	5.75
	Final harvest	3.14	17.97	0.42	21.53
	Total	3.98	22.76	0.54	27.28
2	Thinning	15.92	4.79	2.04	22.75
	Final harvest	3.14	17.97	0.42	21.53
	Total	19.06	22.76	2.46	44.28

		Average per ha GHG Emissions Avoided per Year (±s.d.) (tCO_2-e ha^{-1} year^{-1})			
Scenario	Residue Alternative	50 km	100 km	200 km	300 km
1	1	**4.61 ± 0.27**	4.60 ± 0.27	4.53 ± 0.27	4.51 ± 0.27
	2	**7.36 ± 0.43**	7.32 ± 0.43	7.24 ± 0.44	7.2 ± 0.44
2	1	**1.24 ± 0.04**	1.23 ± 0.04	1.19 ± 0.04	1.15 ± 0.04
	2	**1.99 ± 0.07**	1.96 ± 0.06	1.90 ± 0.06	1.84 ± 0.06
3	1	1.49 ± 0.18	1.47 ± 0.17	1.44 ± 0.17	**1.38 ± 0.17**
	2	2.38 ± 0.27	2.35 ± 0.28	2.29 ± 0.28	**2.23 ± 0.29**

Costs and barriers along the forest biomass supply chain in Australia relative to the EU

- **S2Biom**, a web-based toolset – capture EU road-side costs
- **3-round Delphi** to estimate directional (higher/lower) and proportional (range) difference for Australia

Section	Residue types	Response options	
Road-side costs	Stemwood – thinnings		<10%
	Stemwood – final harvest	Lower	11-20%
	Logging residues – thinnings	Equal	21-30%
	Logging residues – final harvest	Higher	>30%
	Stumps – final harvest		I don't know
Transport costs	Forest residues		

Costs and barriers along the forest biomass supply chain

3-round Delphi study

Round 1 survey (n=10 experts)

- EU cost data (S2Biom) – experts estimated directional and proportional difference for Au

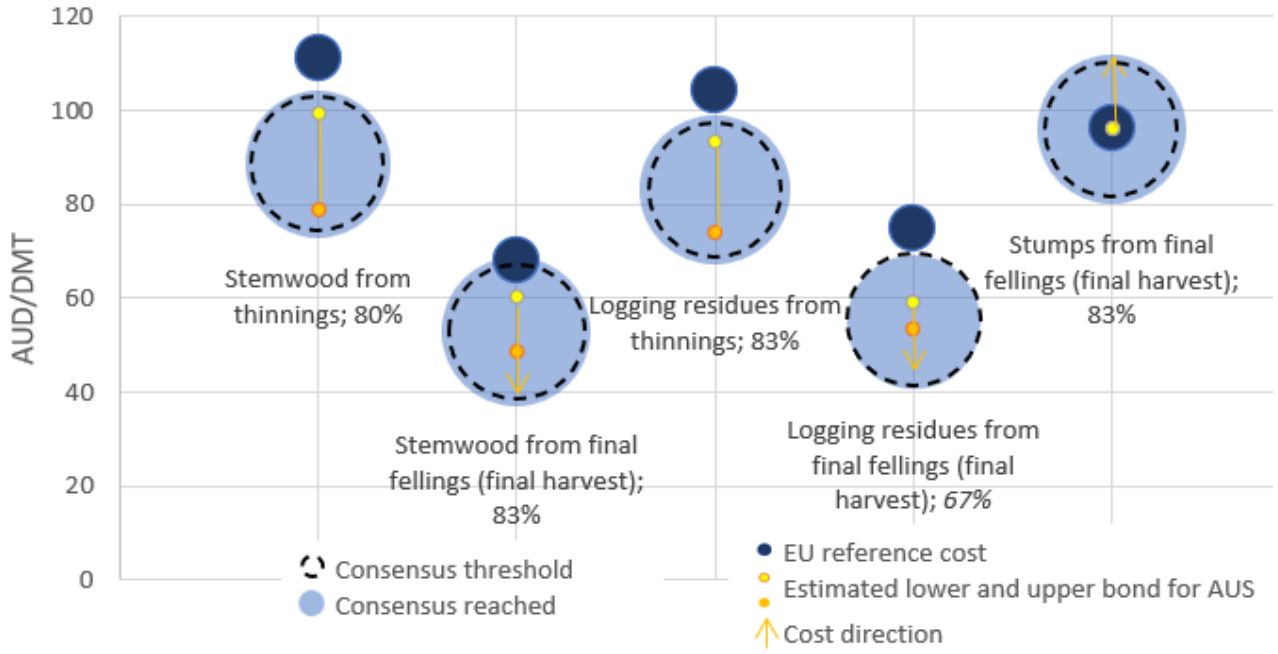
Round 2 survey (n=6 experts)

- experts provided R1 cost ranges/group consensus and challenged to narrow responses
- expert opinion on 43% emissions reduction target

Round 3 interviews (n=6 experts)

- R2 cost range/group consensus
- experts give qualitative comments

Delphi study on biomass supply costs



Stemwood and logging residue costs were estimated to be **lower in Australia** than the EU

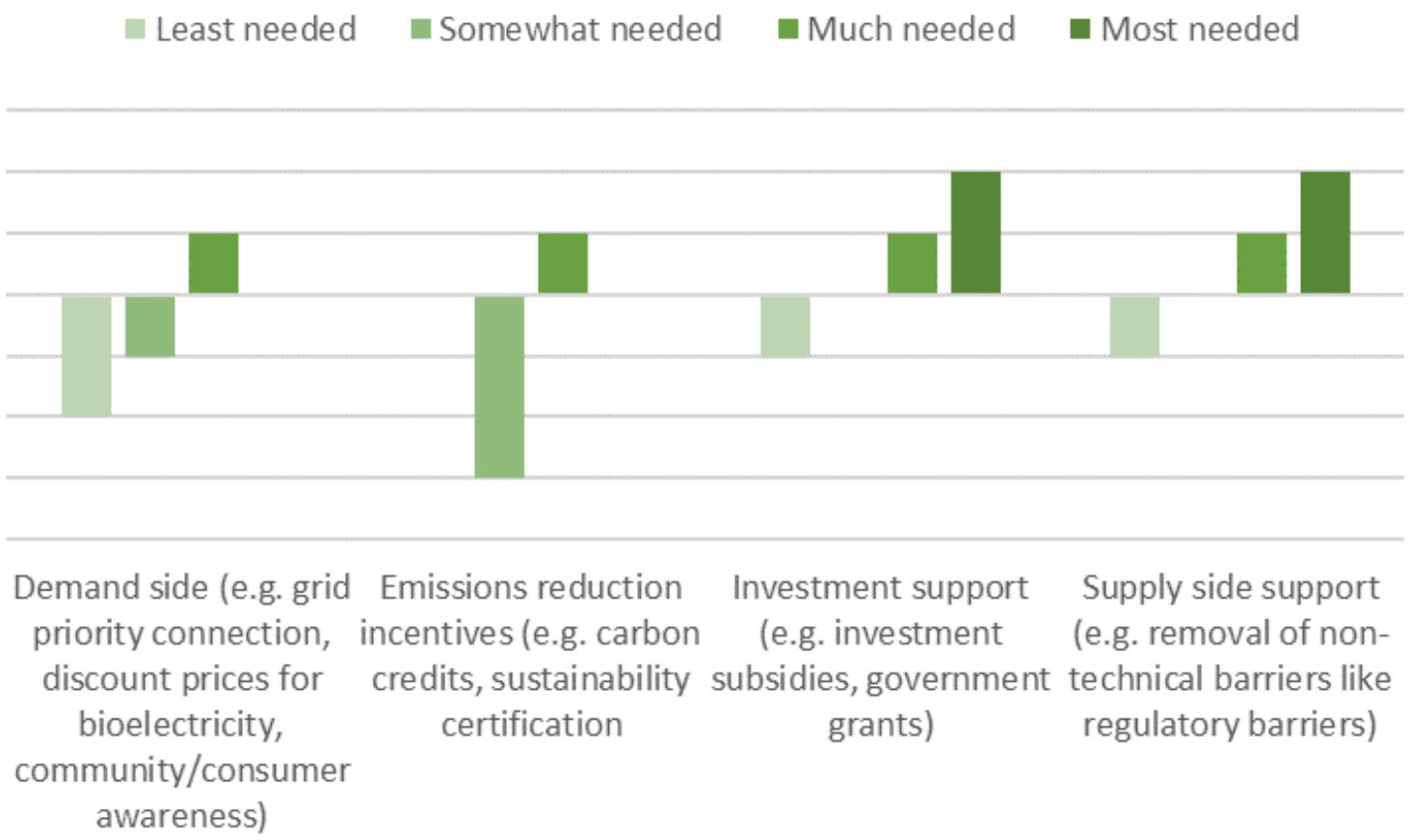
*Thinning, costs estimated to be **11 to 30% lower:**

- AUD 78-99/DMT (stemwood)
- AUD 73-93/DMT (logging residues)

Stumps and transport costs were **equal or higher**

Residue type	Cost direction
Thinning*	11-30% lower
Final harvest - stemwood	> 10% lower (<AUD60/DMT)
Final harvest - logging	> 20% lower (<AUD59/DMT)
Stumps	Equal or 10% higher
Transport	Equal (AUD9/km) or higher

Support priorities for bioenergy market development



- **A call for a policy framework with mechanisms providing greater support emerged from this study**
- Government agencies eg Clean Energy Finance Corporation, Emissions Reduction Fund administering carbon credits under the Clean Energy Regulator 2023, and the Australian Renewable Energy Agency (ARENA) geared to support development of renewable energy projects.
- State-based initiatives also exist.

Support priorities for bioenergy market development

67% experts

- Australia's 43% emissions reduction target legislated in September 2022 would contribute to the development of the bioenergy market

33% experts

- emissions target is not a key driver of bioenergy development given Australian legislative frameworks and mechanisms such as the Emissions Reduction Fund are not particularly attractive to designers of biomass projects
- strong international demand is likely to continue to drive biomass exports

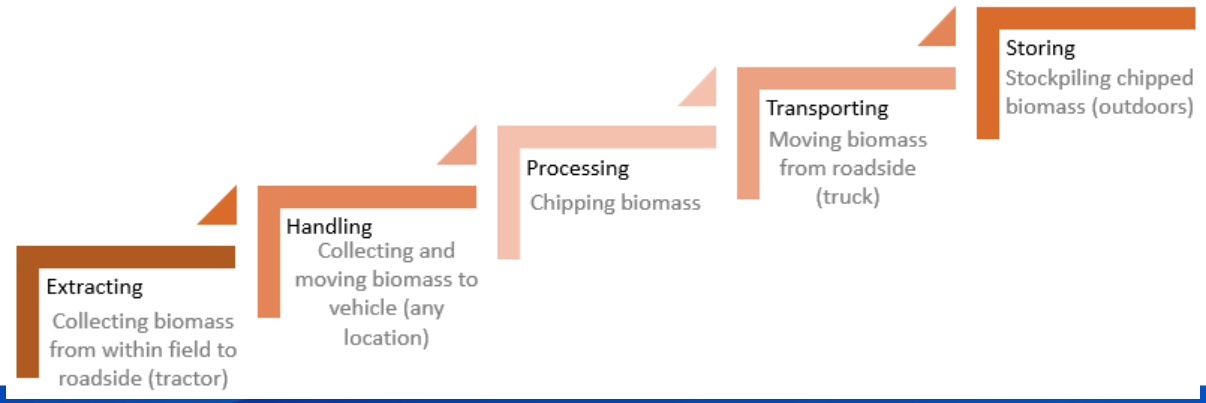
- ABARES – woodchip exports will be largest market (up to 0.8 mt) for forest residues in 2050
- expansion of other renewable energies is incentivised by national and state regulatory frameworks:
  - five years to 2021, domestic wind (two-fold) and solar electricity (four-fold) consumption increases

Efficient delivery of forest biomass to the Australian bioeconomy

- Analytical Hierarchy Process (AHP) to rank and assess importance of supply chain processes using pairwise comparisons:

Alternative	Biomass supply pathways
A1	Extracting and chipping in the field
A2	Extracting and transporting to roadside, chipping at roadside
A3	Extracting and transporting to roadside, then transporting to conversion facility gate, chipping at conversion plant.

- Simple ranking model - 5-point Likert scale to:
  - investigate overall cost significance of biomass supply processes:



AHP to rank biomass supply chain pathways

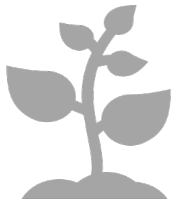
- **Extracting and chipping in the field** (A1 pathway) weighted at twice the second alternative:
  - **Extracting and transporting to roadside, chipping at roadside** (A2), and about 5-6 times more than the last ranked biomass supply pathway:
    - **Extracting & transporting to roadside, then transporting to conversion facility gate, chipping at conversion plant** (A3).

Simple ranking of biomass supply chain processes

	Overall Rank	Rank Distribution
Extraction - collecting from within field to road-side (tractor)	1	
Processing - chipping biomass	2	
Transporting - from road-side (truck)	3	
Handling - collecting and moving to vehicle (any location)	4	
Storing - chipped biomass (outdoors)	5	

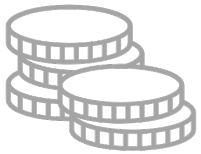
- **Extraction** had the highest cost ranking - twice as high as the lowest cost item: **storing**
- **Transporting** ranks behind extracting and close to chipping material (processing)
  - contrasts to commonly held assumptions and past research
  - residue utilisation in Australia is mostly by co-located plants where transport distance is low
  - transporting and processing sensitive to fuel/oil prices given high fuel demands

Forest residues for the bioeconomy - Summary



large volumes of forest residues are available in Australia

12,773 to 20,798 tonnes of GHGe per year could be avoided by replacing coal-fired electricity with CHP



Stemwood and **logging residue costs lower** in Australia compared to EU

Stump, transport costs estimated to be **equal or higher** in Au than EU

Supply-side support eg removal of barriers in greatest need

Extracting and chipping in field most efficient pathway for forest residues

Extracting, processing, transporting highest cost profiles in Au

Forest residues for the bioeconomy – Next steps…

- Other emerging products eg biochar, bioplastics, biochemicals
- Social sustainability benefits and trade-offs
- SDG benchmarking
- Soil impacts, further supply chain support, alternative residues