

**Renewable energy - Is it really
that good?**

A life cycle perspective.

**Timothy Grant
Director, Lifecycles**

Lifecycles – Who we are

- Established in 2003 (Life Cycle Strategies Pty Ltd)
- Based in Melbourne, Australia

Our mission

- Enabling organisations to use better metrics for sustainability for decision making and communication.

What we do

- Life Cycle Assessment (LCA) & circular economy consulting
- LCA Training
- Life Cycle Inventory Database Development
- Sustainability Software Development

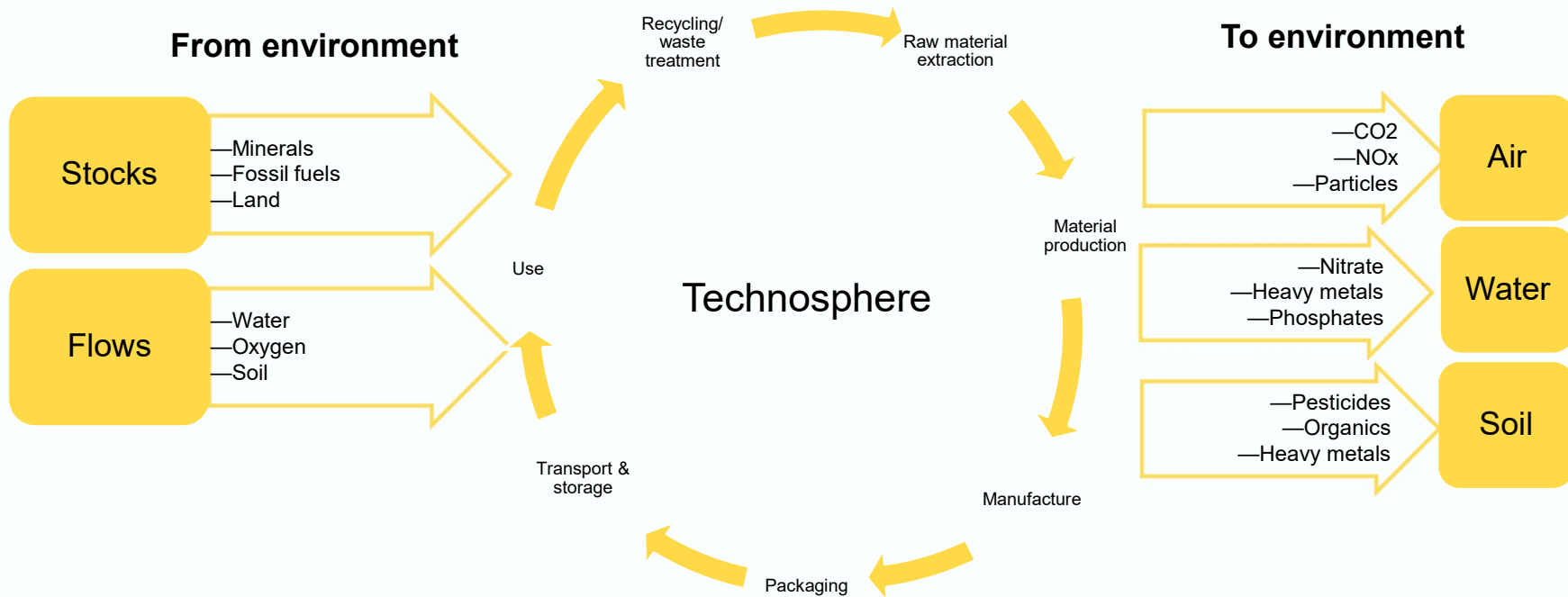


What is Life Cycle Assessment (LCA)?

An internationally standardised approach to evaluation the potential environmental impacts of products and services by:

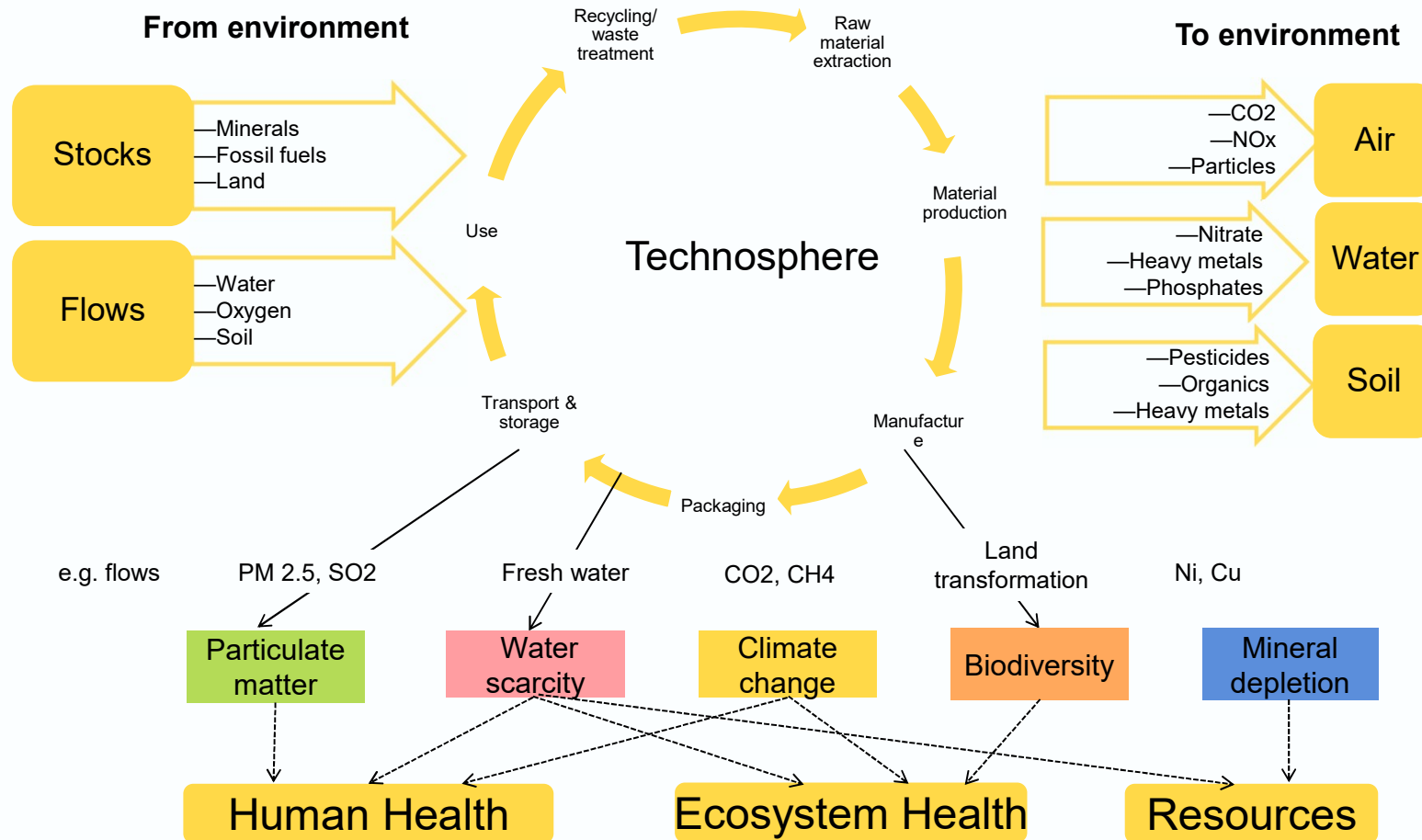
Evaluating the inputs and outputs of product system over the entire life cycle.

Inventory flows – interaction between the economy and the environment



Flows to and from the environment

- linked to impacts pathways and environmental indicators



How do we determine how “good” it is

1. Evaluate functionally equivalent services



2. Evaluate across a broad range of environmental indicators



What is the scope of renewable energy end uses?

- Renewable electricity
- Renewable fuels for transport (aviation in particular)
- Renewable reductants
 - coal, coke, char etc



What are our measures of “good”

- Broad based indicator set
- “environmental footprint” method
 - developed by EU.



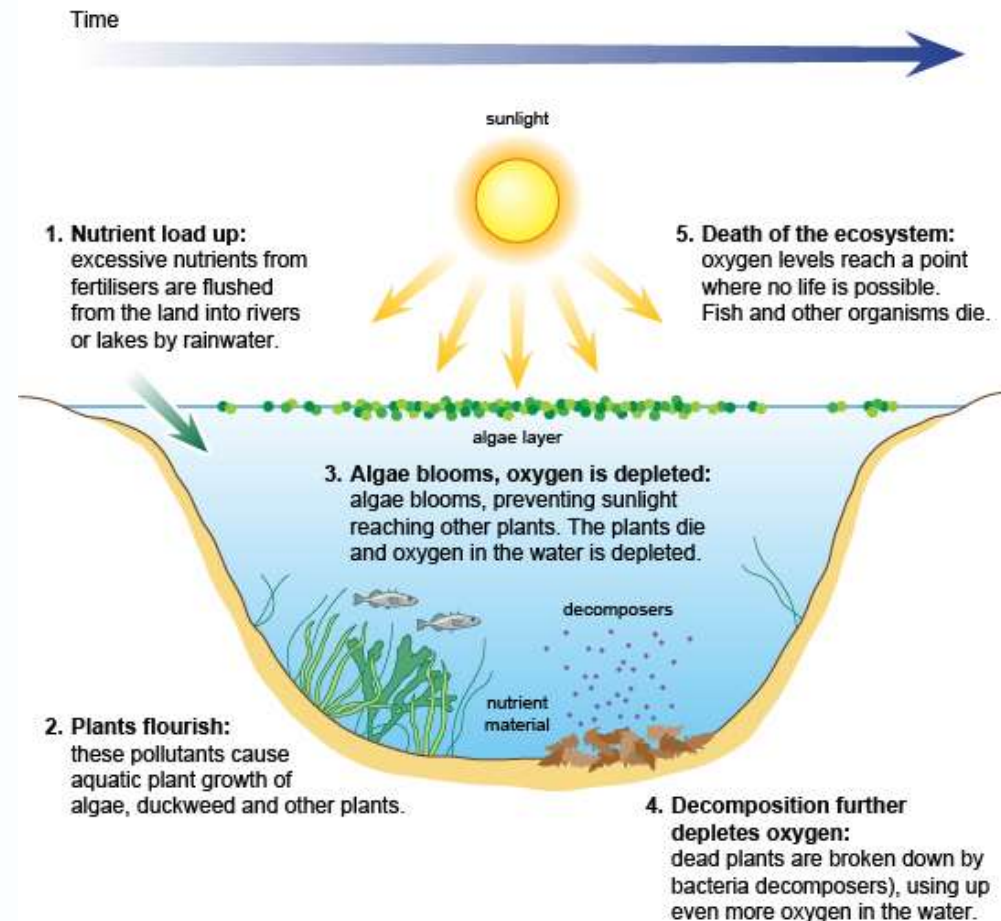
Human health Indicators

- Climate change
- Particulate matter
- Human toxicity, cancer
- Human toxicity, non-cancer
- Ionising radiation
- Ozone depletion
- Photochemical ozone formation potential (PCOP)



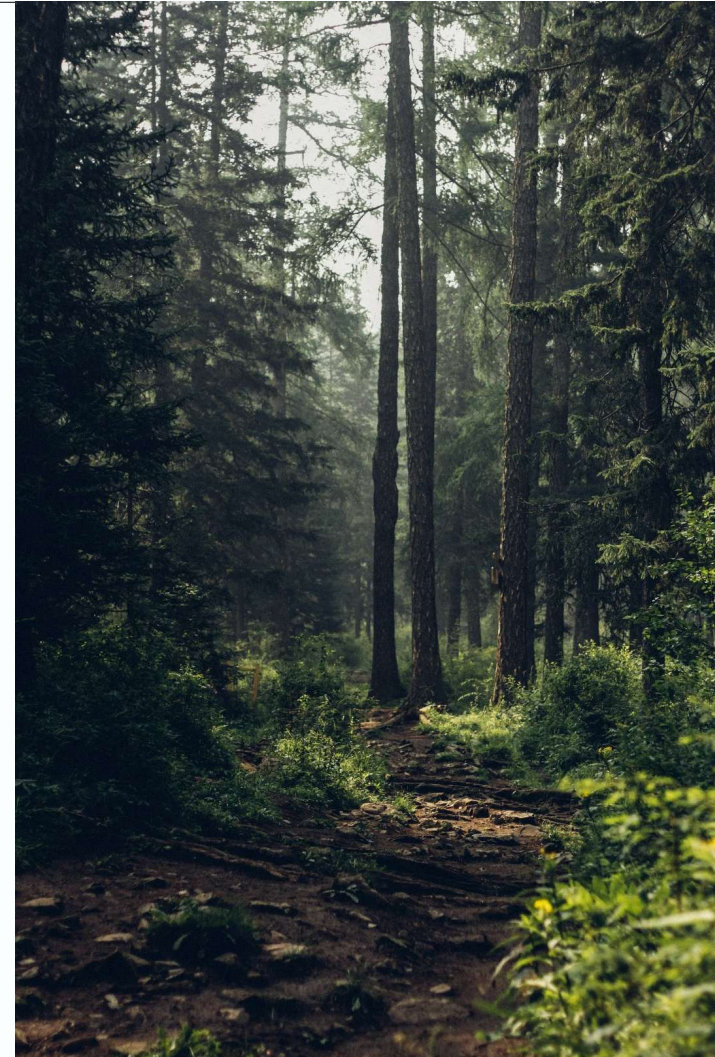
Ecosystem damage indicators

- Acidification
- Eutrophication, marine
- Eutrophication, freshwater
- Eutrophication, terrestrial
- Ecotoxicity, freshwater



Resource damage indicators

- Resource use, fossils
- Resource use, minerals & metals
- Water use
- Land use



Electricity

- Most dominant application of renewable energy
- Is leading to transition of other technologies to be based electricity as major energy input.
- Functionally all electricity delivery is very similar



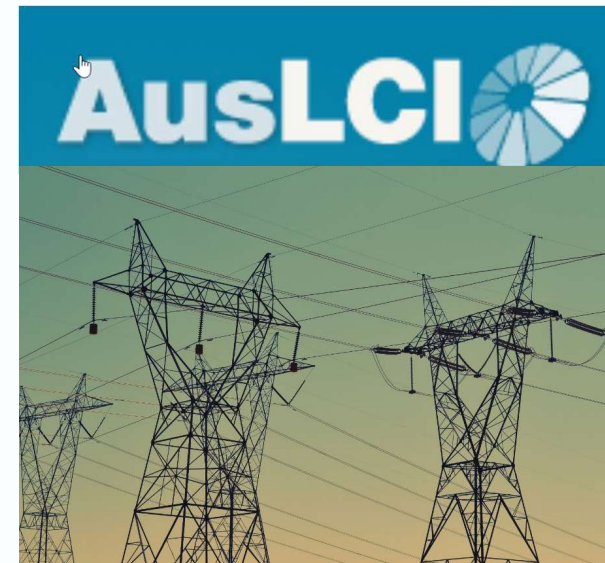
Functionally useful electricity

- Electricity supply
 - day in day out
 - year in year out

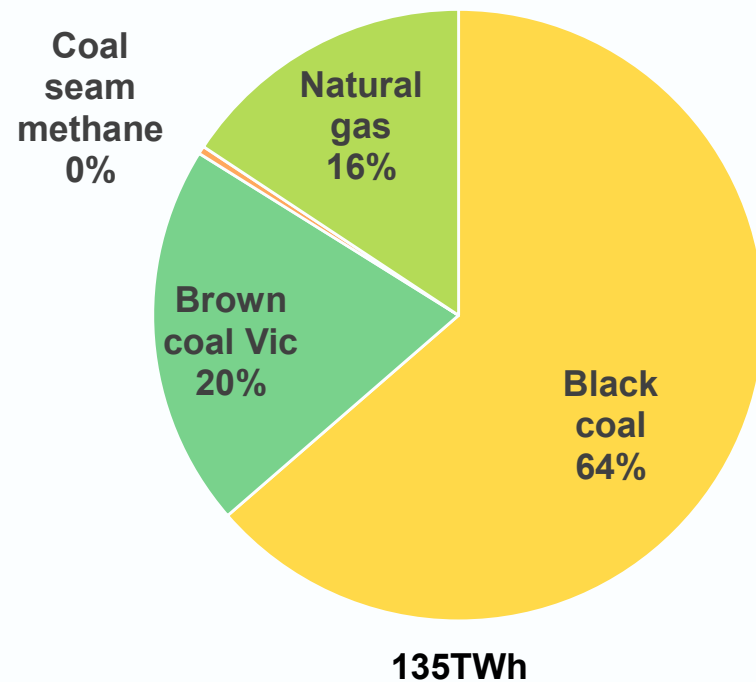
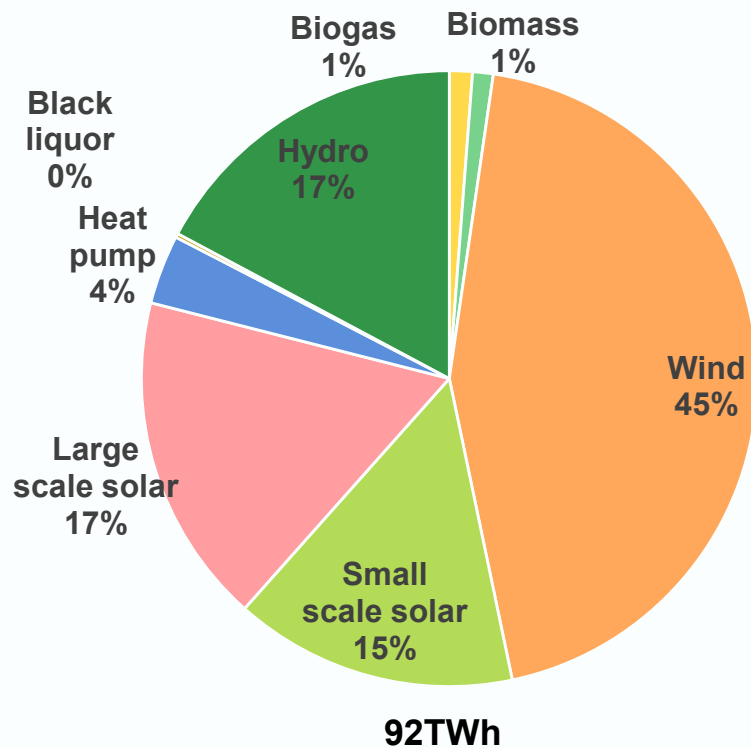


Comparing existing technologies

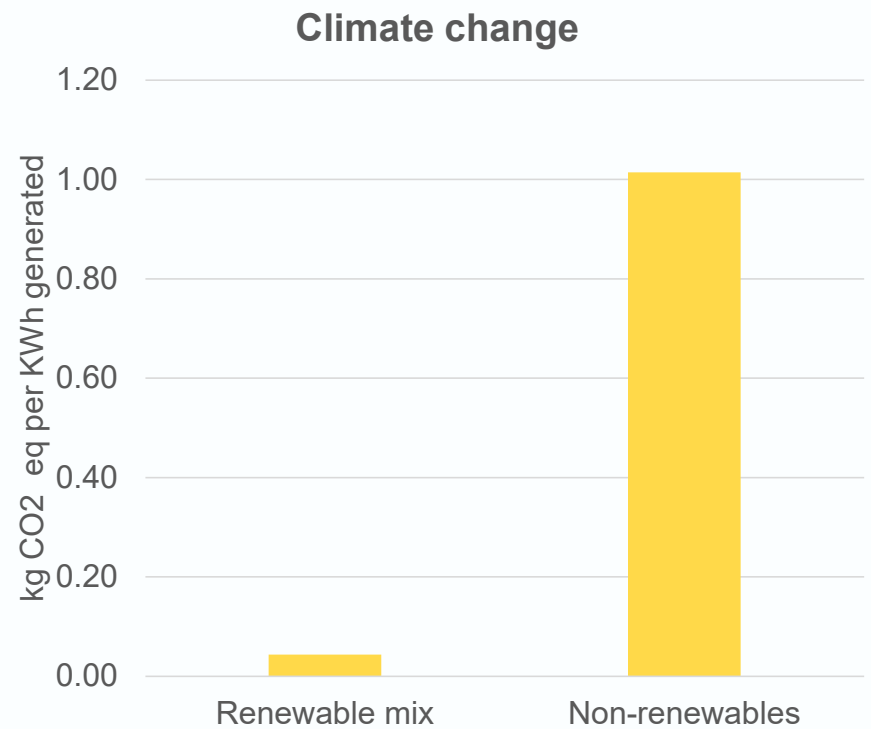
- From Australian Life Cycle Inventory Database (AUSLCI)
- Supplemented by Ecoinvent (Swiss based global life cycle inventory database)
- Cradle to generation – including infrastructure elements excluding transmission and distribution
- Transmission and distribution typically add additional 4-8 percent



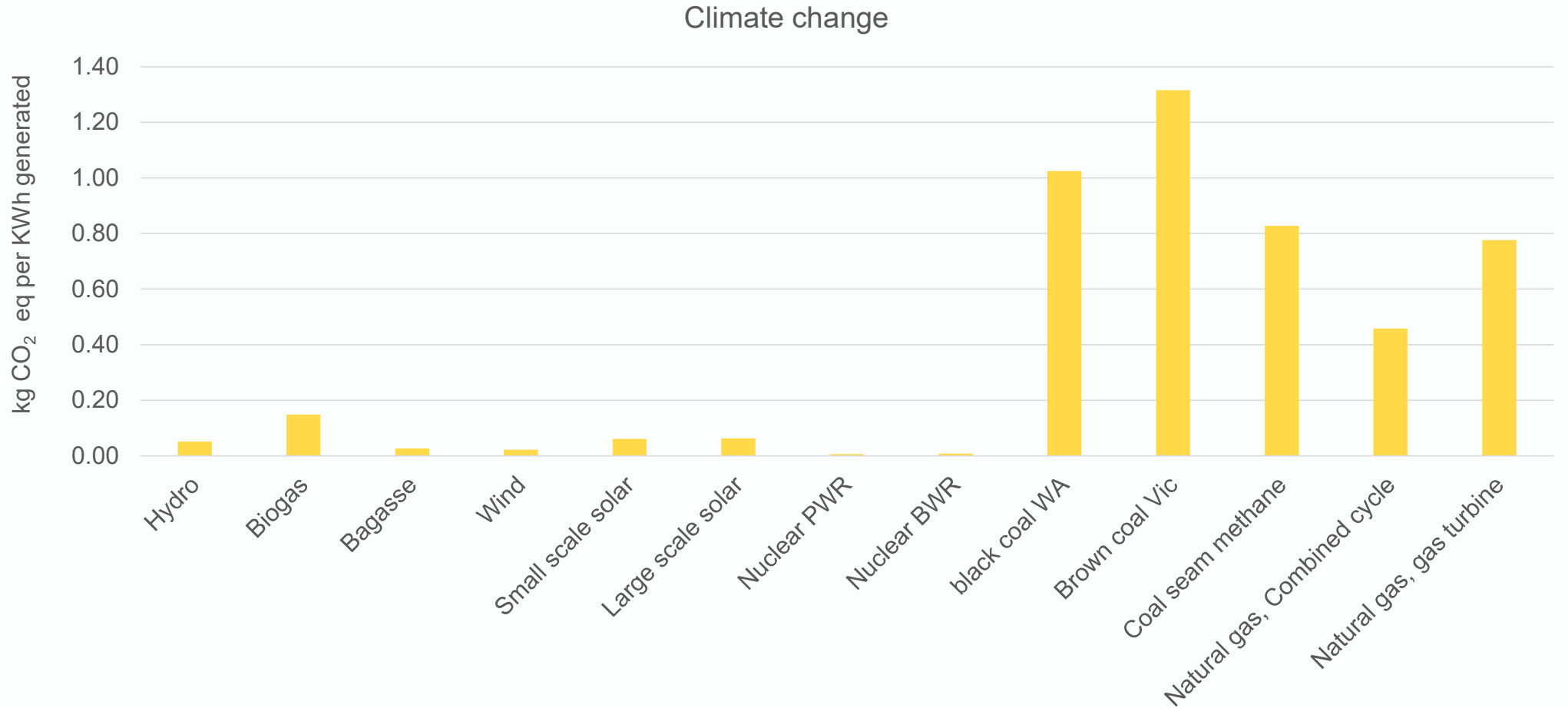
Existing renewables & non-renewable mix in Australia



1 kWh of current renewable mix and current non-renewable mix in Australia



Climate impact by generation technology



Human health related indicators

	Hydro	Biogas	Bagasse	Wind	Small scale solar	Large scale solar	Nuclear PWR	Nuclear BWR	black coal WA	Brown coal Vic	Coal seam methane	Natural gas, CC	Natural gas, GT
Climate change	5.1E-02	1.5E-01	2.6E-02	2.2E-02	6.1E-02	6.3E-02	6.5E-03	7.5E-03	1.0E+00	1.3E+00	8.3E-01	4.6E-01	7.8E-01
Particulate matter	7.2E-10	1.1E-08	3.0E-07	2.3E-09	4.5E-09	4.7E-09	3.6E-09	3.6E-09	5.3E-08	1.4E-07	4.7E-09	7.8E-09	7.4E-09
HT, cancer	2.5E-12	3.8E-11	1.8E-10	3.9E-11	4.5E-11	3.6E-11	5.1E-12	4.9E-12	3.6E-11	4.8E-11	2.9E-09	3.5E-12	2.4E-12
HT non-cancer	6.5E-11	9.6E-10	7.0E-09	2.2E-09	3.0E-09	2.0E-09	2.3E-10	2.3E-10	3.7E-09	4.7E-09	5.0E-10	2.3E-10	1.9E-10
Ionising radiation	2.8E-04	3.5E-03	2.3E-04	1.0E-03	5.0E-03	4.8E-03	6.9E-01	1.2E+00	1.9E-04	9.3E-05	4.5E-05	4.1E-05	3.6E-05
Ozone depletion	3.2E-12	3.4E-11	3.7E-11	1.2E-10	4.5E-09	4.3E-09	2.2E-11	1.9E-10	2.0E-11	1.9E-11	3.4E-12	1.3E-11	5.7E-12
PCOP	2.9E-05	6.8E-04	2.3E-03	1.1E-04	2.8E-04	2.7E-04	4.7E-05	5.0E-05	5.1E-03	2.8E-03	1.2E-03	3.4E-04	5.7E-04

Ecosystem related indicators

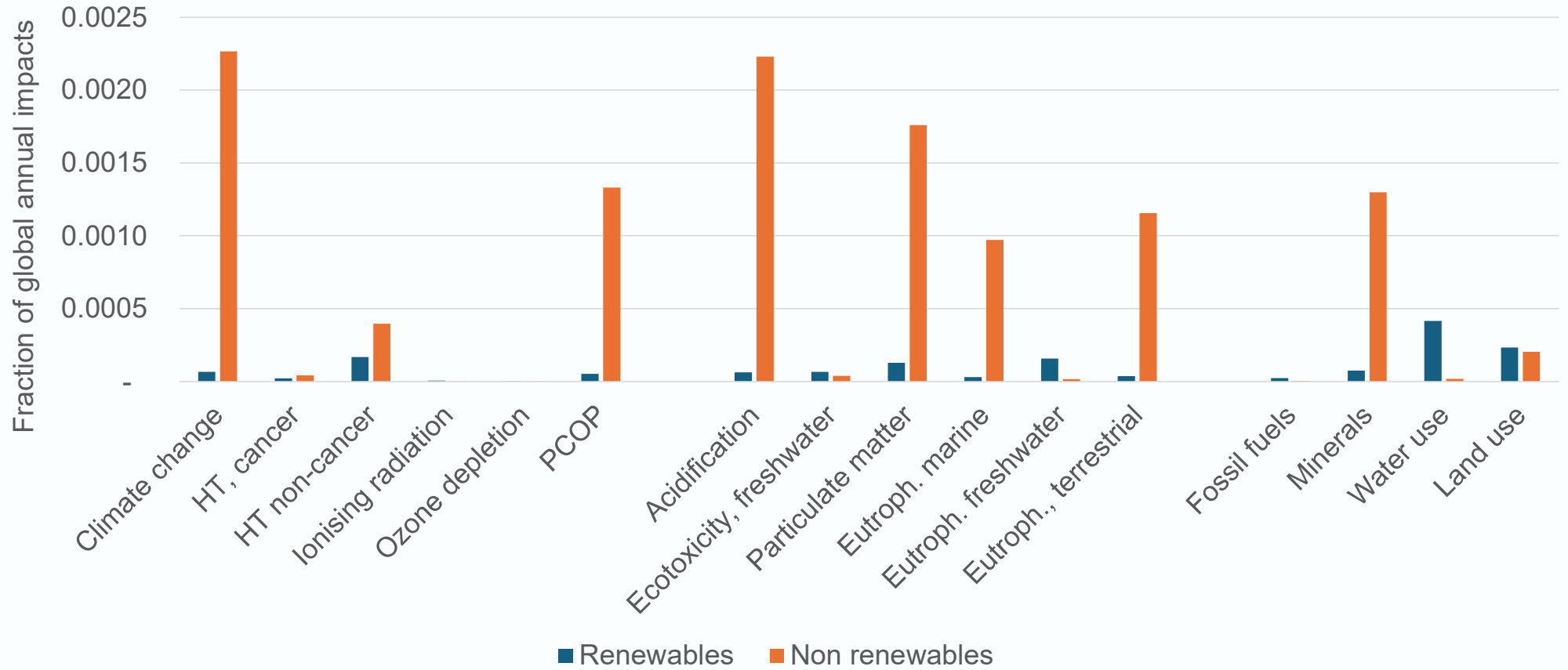
	Hydro	Biogas	Bagasse	Wind	Small scale solar	Large scale solar	Nuclear PWR	Nuclear BWR	black coal WA	Brown coal Vic	Coal seam methane	Natural gas, CC	Natural gas, GT
Acidification	2.8E-05	1.1E-03	2.0E-03	2.6E-04	4.8E-04	4.0E-04	5.4E-05	5.8E-05	8.2E-03	1.2E-02	2.9E-04	4.6E-04	8.4E-04
Eutroph. marine	8.2E-06	1.2E-04	8.9E-04	3.2E-05	7.2E-05	7.0E-05	5.8E-05	5.9E-05	1.9E-03	8.5E-04	1.4E-04	1.2E-04	1.7E-04
Eutroph. freshwater	1.8E-06	3.8E-05	8.8E-06	2.1E-05	4.0E-05	3.2E-05	4.2E-06	4.8E-06	2.0E-06	1.6E-06	7.6E-07	9.8E-07	9.4E-07
Eutroph., terrestrial	8.9E-05	1.9E-03	1.0E-02	3.5E-04	7.6E-04	7.5E-04	1.5E-04	1.6E-04	2.0E-02	9.0E-03	1.5E-03	1.1E-03	1.9E-03
Ecotoxicity, freshwater	1.9E-02	4.0E-01	7.5E-01	3.0E-01	6.0E-01	4.8E-01	7.0E-02	7.1E-02	1.1E-01	6.2E-02	5.9E-02	1.5E-02	1.4E-02

Resource related indicators

	Hydro	Biogas	Bagasse	Wind	Small scale solar	Large scale solar	Nuclear PWR	Nuclear BWR	black coal WA	Brown coal Vic	Coal seam methane	Natural gas, CC	Natural gas, GT
Fossil fuels	3.2E-05	6.7E-01	1.4E-02	1.4E-04	2.9E-05	1.5E-07	1.3E-07	1.2E-07	1.2E+01	1.4E+01	1.1E+01	7.9E+00	1.3E+01
Minerals	2.8E-08	3.0E-07	1.5E-07	2.7E-06	4.3E-06	2.6E-06	1.3E-07	1.2E-07	5.3E-08	1.0E-07	7.8E-08	1.2E-07	1.2E-07
Water use	1.2E+00	7.7E-03	1.2E-02	9.4E-03	6.0E-02	5.9E-02	2.2E-02	1.5E-01	1.9E-01	1.7E-01	5.4E-02	1.1E-01	6.5E-03
Land use	-6.4E-01	1.1E+00	1.9E+00	2.4E-01	2.6E-01	9.4E+00	4.2E-02	4.5E-02	3.7E-01	5.1E-02	3.3E-02	4.6E-02	4.2E-02

Are all indicators equal?
...How to differentiate!

Contribution of 1 year current electricity showing renewables and non renewables contribution to global total impacts in each category (normalisation)



What about balancing the grid?

- Traditionally electricity grid has been about baseload (met by coal generators) and peak generation (met by gas, hydro).
- The new reality is peak supply is during the day from solar and wind and due to the intermittent nature of renewables, there is a need for alternative generators or storage low generation times.
- Filling this gap in generation is referred to as “firming” the grid mix
 - Possible firming could be supplied by natural gas generation or increasingly by battery and other storage.
 - Firming percentage at worst is likely to be 5 to 10 percent

Policy & Planning

Dan Tehan fails to grasp difference between baseload and firming as he sprouts nonsense on nuclear

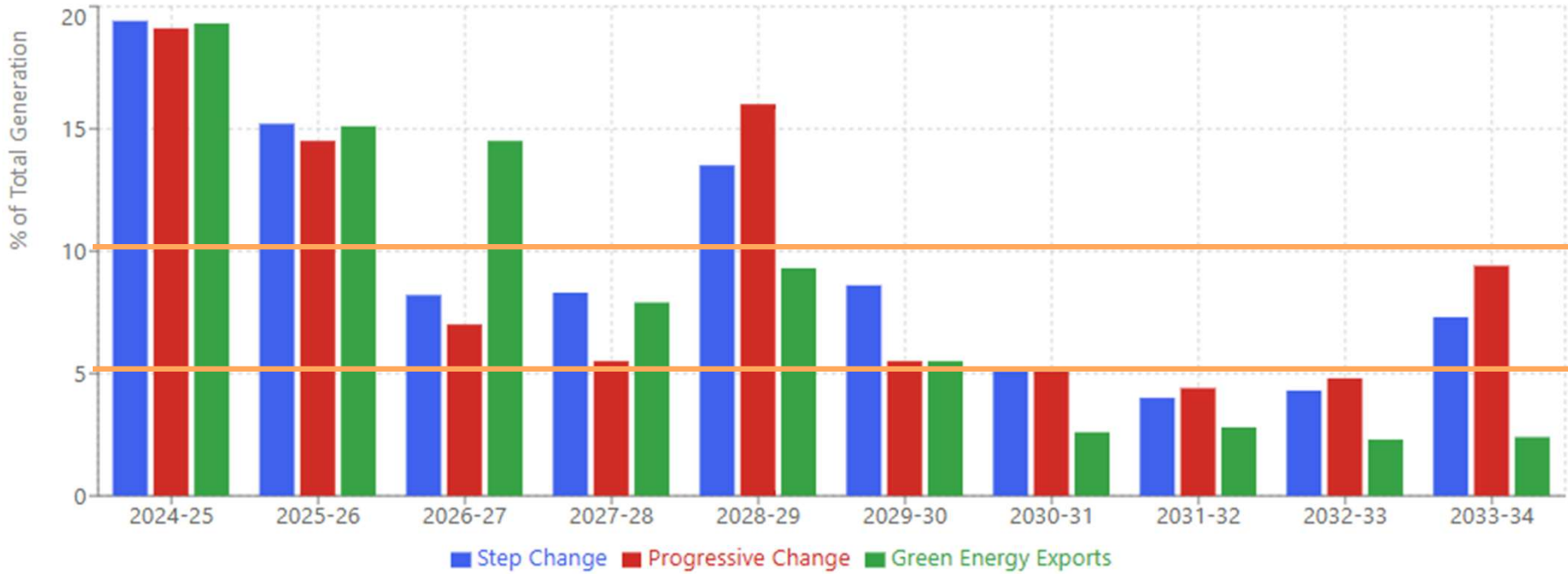
Giles Parkinson

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Gas & diesel generation predictions by Australian Energy Market Operator (AEMO) in SA

Gas Generation as Percentage of Total Generation



Australian grid with gas turbine firming or additional lithium-ion battery storage

Australian current annual emission from electricity is 170 Mt CO₂e

Providing firming with natural gas turbines for 5% of grid demand would emit roughly 8.5 Mt CO₂e

South Australian Tesla battery (194MWh) footprint approximately 0.016 Mt CO₂e

Divided by 20 year 0.008 Mt CO₂e

Transmission and distribution

- Transmission was traditionally one directional from large generators to users
- With expanded renewables there is
 - Energy use behind the meter
 - Bi-directional energy transmission of electricity
 - Stress to existing infrastructure but not reason to think there is increase in distribution

Why is solar and wind so good?



Rule of thumb - Things which happen once every 10-20 years versus thing which happens every day.

- House construction versus use
- Car production versus car use
- Water pipes versus pumping water

Imagine having solar panels as the main power source and suggesting burning coal for energy.

But what about all the PV and battery waste

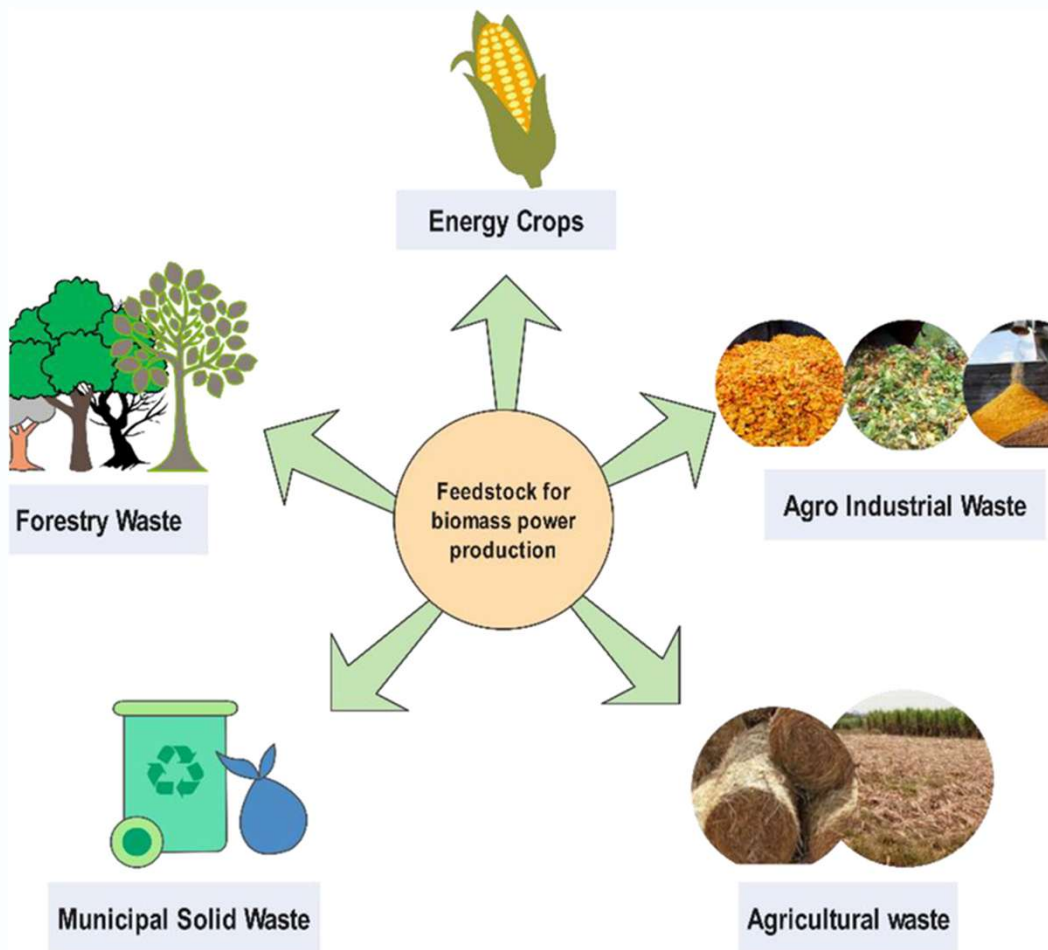
- LCA shows the resource loss is the problem with waste – rarely the disposal
- Materials in large scale batteries and solar panels are valuable, at scale, and managed by small group of actors.
- We are likely still on the early part of the renewable energy technology curve

What about renewable liquid fuels?

Needed for road freight for some time
For aviation fuel for foreseeable future



Liquid fuels require some feedstock



- Uses waste feedstocks
 - Lower value lower yields
 - Constrained in supply
- Use energy crops
 - Better feedstock
 - Scalable
 - Impacts of land and water

Queensland biofuels LCA from 2018

	Climate change	Fossil energy depletion	Eutrophication	Particulate matter	Land use	Water scarcity
	% improvement (+ve) on competing fossil fuels					
Ethanol sugarcane	42%	76%	-1384%	-48%	79%	-19979%
Ethanol from sugar cane trash	84%	89%	46%	57%	92%	-90%
Biodiesel canola	52%	67%	-2555%	-36	-87%	-227%
Renewable diesel forestry wastes	76%	138%	0%	82%	161%	118%
Renewable diesel pyrolysis of woody weeds	80%	142%	3%	85%	164%	125%

Grant, T. (2018). Greenhouse gas and sustainability footprints of emerging biofuels for Queensland. Melbourne, Australia, Lifecycles.

Reducing agents – coal, coke, char

Big users will transition to alternative pathways

- Steel – to direct reduction using hydrogen

Bio-char can be made with pyrolysis of biomass

- Feedstock supply is a constraint
- Relatively expensive



Renewable energy is changing the economy

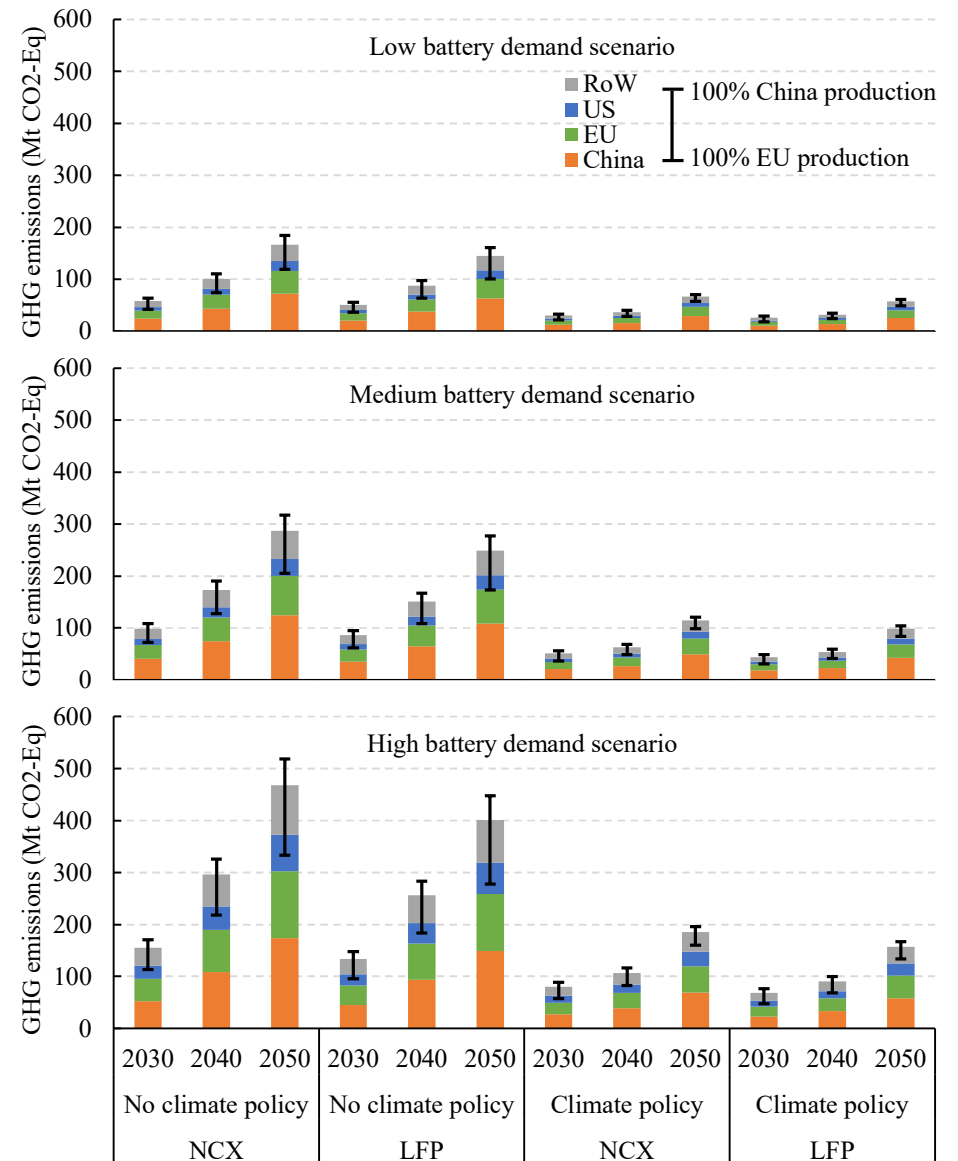
- 34% of footprint of renewable electricity footprint is other electricity
- The energy transition impacts are reliant on the energy transition!!



Global transition to an EV fleet

- How will EV battery impacts change over time?
- Depends on
 - Battery technology choice ((Nickel-Cobalt/NCX versus Lithium Iron Phosphate/LFP)
 - Speed of electricity transition
 - Size of vehicles and size of vehicle fleet
 - Production proportion in China versus EU

Presented by Arnold Tucker at 12th Australian Conference on LCA, November 18-20 2025, Melbourne Australia



Renewable energy is changing the economy

- Aluminium can be made with a carbon footprint less than plastic (PET)
- If energy was essentially “free” how different is the world and technologies?
- All LCA studies need to be recalibrated as the ways of manufacturing is in dramatic transition



Conclusions

- Yes, renewables are very good and are getting better.
 - Liquid fuels and aviation remain less positive with all feedstocks having some issues
- The energy transition is maybe the most amazing thing humans has ever achieved – against all the odds and vested interests.

Lifecycles. Get the whole picture.



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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