Circular Economy, Energy Recovery, and Emerging Pathways

Daniel Roberts

The 2021 WARRQ Conference, 21 October 2021, Bundaberg, QLD.

Australia's National Science Agency

Outline

How circular economy and other emerging drivers are shifting the (international)thinking regarding waste, energy, and resource recovery.

- Background: Our work with IEA Bioenergy (Task 36)
- The emerging impact of Circular Economy on Waste Management (and energy recovery)
- Technology implications
- New pathways and sectors

→ Not so much 'this is what we should do now', as work is needed, especially in Australia. Rather, it's a perspective on the kinds of change needed to truly have CE and lowC transitions.

IEA Bioenergy

Bioenergy Australia and IEA Bioenergy

IEA Bioenergy

Set up by IEA to improve cooperation and information exchange between member countries. The work of IEA Bioenergy is structured into a number of Tasks, which have well defined objectives, budgets, and time frames.

Thanks to funding from the Australian Renewable Energy Agency (ARENA), Bioenergy Australia is able to facilitate Australia's participation in seven IEA Bioenergy Tasks.

Bioenergy Australia and IEA Bioenergy

Task 36 - Material and Energy valorisation of waste in a Circular Economy
Task 37 – Energy from Biogas
Task 39 – Commercialising Conventional and Advanced Liquid Biofuels from Biomass
Task 42 – Biorefining in a future BioEconomy
Task 43 – Biomass Feedstocks for Energy Market
Task 44 – Flexible Bioenergy and System Integration
Task 45 – Climate and Sustainability Effects of Bioenergy within the Broader Bioeconomy

https://www.bioenergyaustralia.org.au/our-work/iea-bioenergy/

Australian Government
Australian Renewable Energy Agency
ARENA
CSIRO

IEA Bioenergy Task 36

Material and energy valorisation of waste in a circular economy








http://task36.ieabioenergy.com/

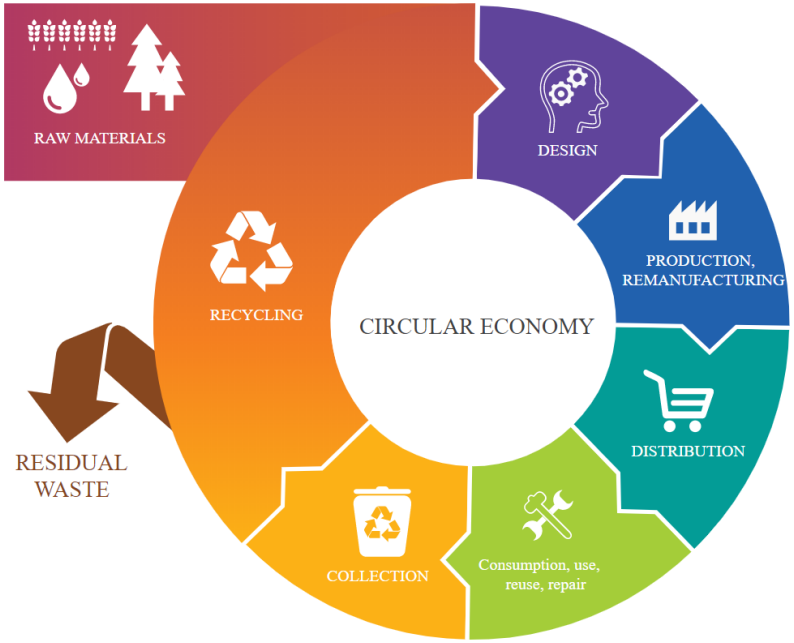
The Circular Economy

The Circular Economy is coming (is here?)

A shift in the production-consumption model.

Keeping products (or their components) in use for longer – thereby reducing waste.

Aspects across manufacturing and supply chains – including the way we design and make things.



https://www.europarl.europa.eu/news/en/headlines/economy/20151201STO05603/circular-economy-definition-importance-and-benefits

The Circular Economy is broad

- Corporate strategies
- Government policies
- System development

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Waste Innovation for a Circular Economy

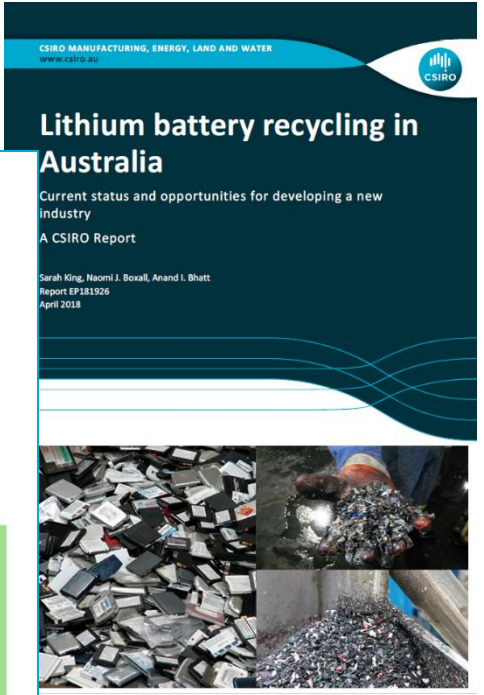
A summary report for the CSIRO Cutting Edge Science and Engineering Symposium

27-29 May 2019, Clayton, Victoria, Australia

Naomi J Boxall, Sarah King, Anna Kaksonen, Warren Bruckard, Daniel Roberts

August 2019

EP195506



CSIRO MANUFACTURING, ENERGY, LAND AND WATER
www.csiro.au

Lithium battery recycling in Australia

Current status and opportunities for developing a new industry

A CSIRO Report

Sarah King, Naomi J. Boxall, Anand I. Bhatt
Report EP181926
April 2018

Implications of CE for waste-to-energy:

Emerging trends from EU

Moving from …

- An inherently linear process
  - Focussed on waste management, with
  - Energy recovery, then
  - Retrofitting technologies to bend this linear process into one that is *more* circular

To …

- Adopting technologies that keep molecules in use for longer
- Systems where energy products and valuable products can be co-produced
- Pathways are inherently circular
- Energy is still important

Technology implications

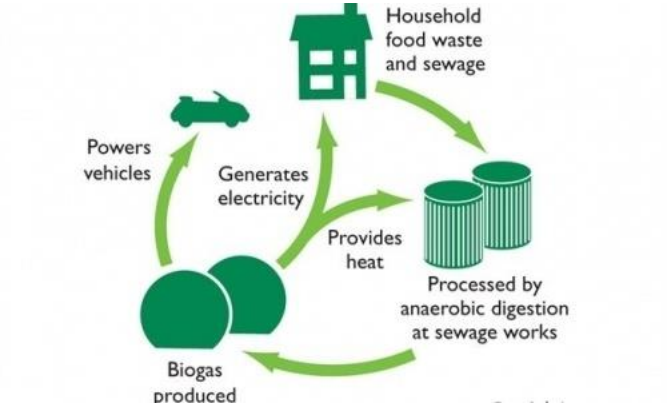
‘Traditional’ Energy Recovery

Combustion

- Heat and power, ash
- Still quite linear

Anaerobic Digestion

- Biogas: power gen, or upgrading to biomethane (renewable methane)
- Residues, sometimes with beneficial utilisation



Implications of CE for waste-to-energy:

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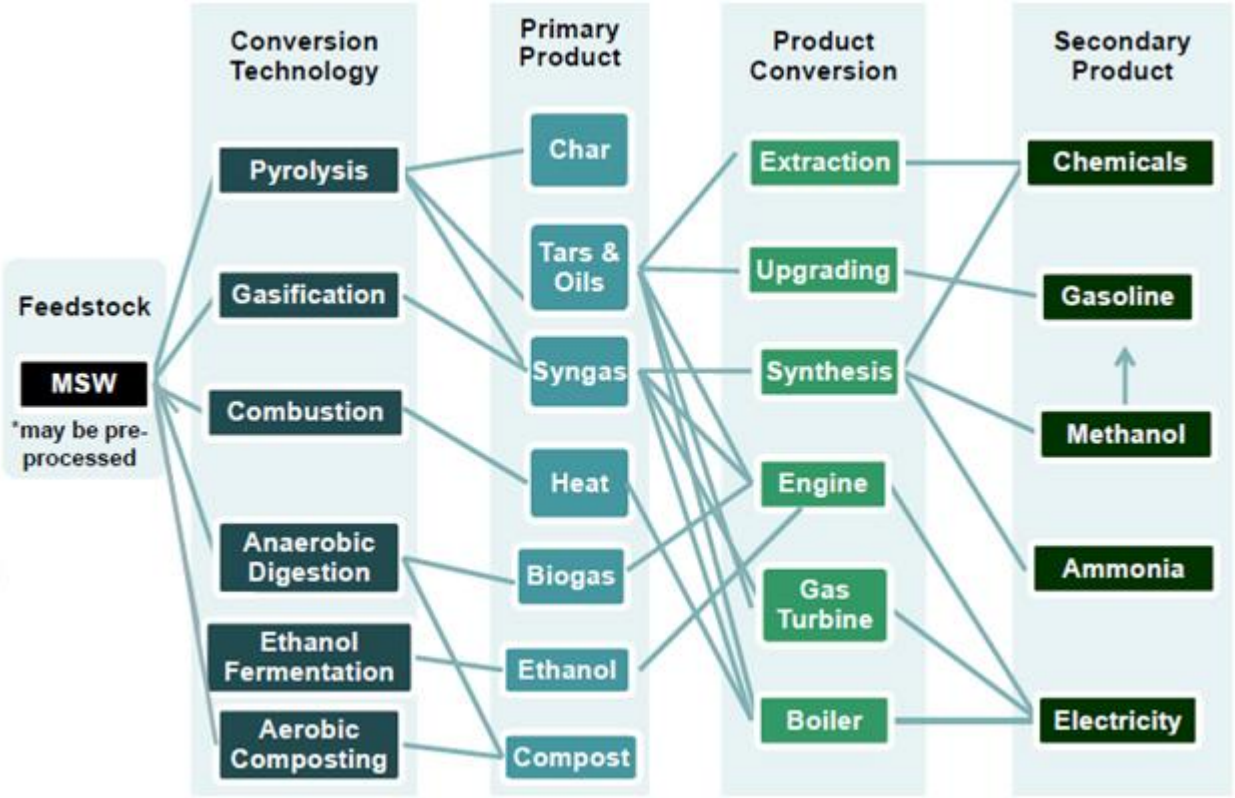
Which makes it complex:



https://www.wastetodaymagazine.com/article/conversion-technology-pathways/

Gasification –> Chemical Recycling

An established and advanced technology

- For large-scale coal to chemicals, fertilisers, power, gas, etc
- Considerable experience with biomass to power, and more recently to products

Much less advanced in the context of waste, esp for non-power applications.

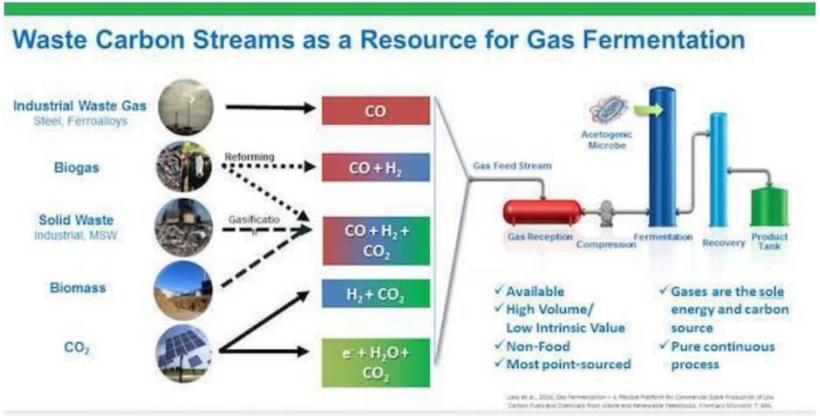
- Many concepts and demonstrations, and many with technical success
- Challenges with project economics
- Some technology-specific challenges with scaling up

Valmet 140MW CFB gasifier for biomass and waste

www.valmet.com/energyproduction/gasification/

https://enerkem.com/media-images/enerkem-alberta-biofuels/

Product diversity (upcycling) with microbiology



https://www.lanzatech.com/

Other examples

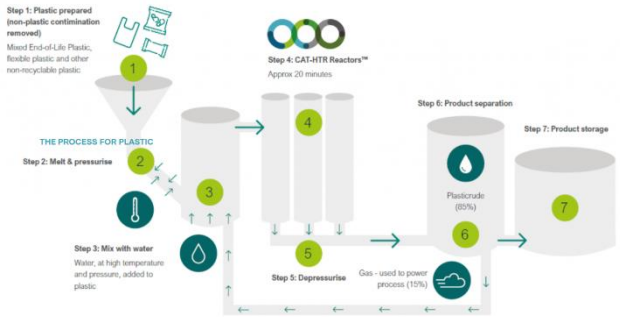
Pyrolysis

- Best suited to homogeneous, well-defined materials: biosolids, tyres, plastics
- Solid char may be suitable for agricultural applications; emerging focus on extracting nutrients

https://arena.gov.au/projects/logan-city-biosolids-gasification-project/

Hydrothermal processes

- Conversion of sludges or plastics to oil, solid fuels, chemicals
- E.g. Licella, Terra Nova, etc.



https://www.licella.com/technology/cat-htr/

BECCS

Not strictly ‘waste’

- Usually woody biomass

Complex value chains

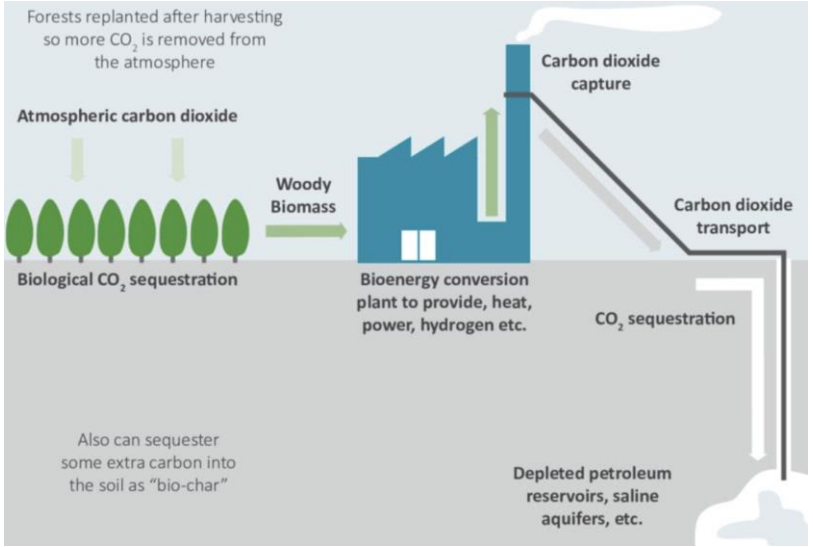
- With plenty of variables

Location, location, location

- Not just from the waste/biomass angle, but also storage.

Expensive

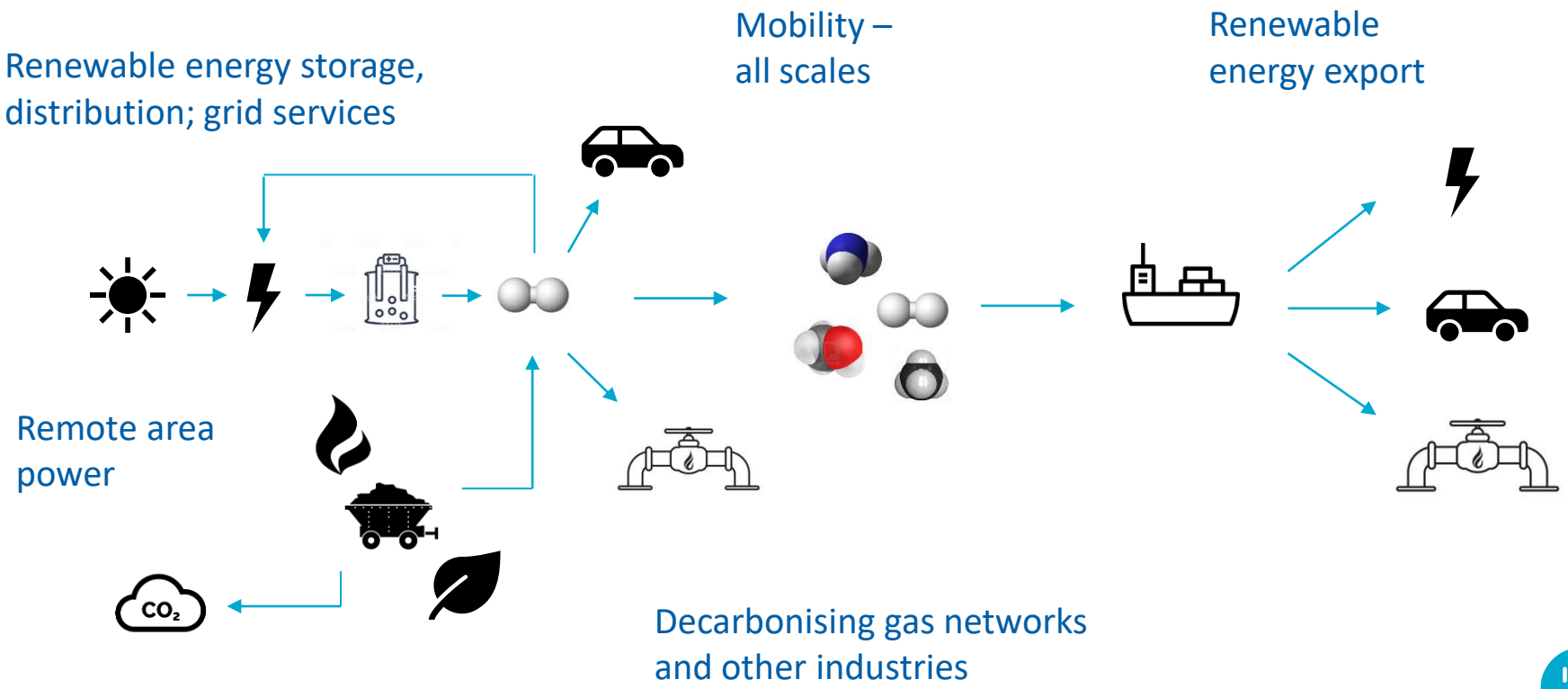
- Especially in a sector already troubled by cost of ‘next gen’.



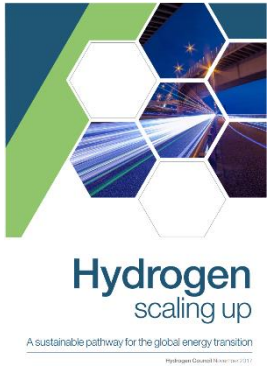
https://earth.org/bioenergy-with-carbon-capture-and-storage-a-silver-bullet-for-carbon-emissions/

The concepts could feature, however, as sectors are coupled, new process are deployed, and new pathways emerge for CO_2 utilisation.

And hydrogen?

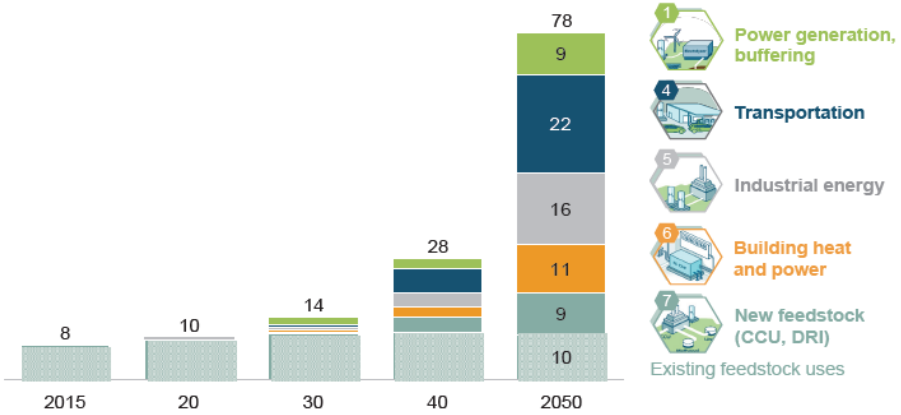


The challenge of scale



By 2050 we could have a global hydrogen demand of 80 EJ

- A 10x increase on 2015, a big shift in usage patterns, and a massive need for ‘carbon-free hydrogen’



How big is 1 EJ?

1 EJ is roughly equivalent to:

- One day of the world’s total final energy demand
- The energy consumed in two years by the transportation sector in the New York metropolitan area
- The heat used by Germany’s steel industry in one year
- The energy required to heat all of the houses in France for one winter
- The energy needed to recycle the annual CO_2 emissions of Michigan’s industrial sector.

http://hydrogencouncil.com/wp-content/uploads/2017/11/Hydrogen-scaling-up-Hydrogen-Council.pdf

Waste to hydrogen pathways

Thermochemical

- Gasification
- Pyrolysis

→ Understood technology blocks; integration and cost/scale will be interesting

Biogas

- Biogas-to-hydrogen

→ Value of biogas-H_2 cf biomethane?

Emerging biological pathways

- Fermentative pathways
- Enzymes
- Bioelectrochemistry

→ Plenty of work still to do.

Summary

Circular economy principles are emerging

- These are already impacting waste management and energy recovery in EU and elsewhere

Technology pathways exist (with plenty more emerging)

- These allow waste streams to be manufacturing feedstocks, which incorporate energy production

Real gains are in the new pathways, rather than via retrofits.

- Plenty of work needed to get the costs and scales needed

Thank you

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