Circular Economy, Energy Recovery, and Emerging Pathways

Daniel Roberts

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Australia’s National Science Agency

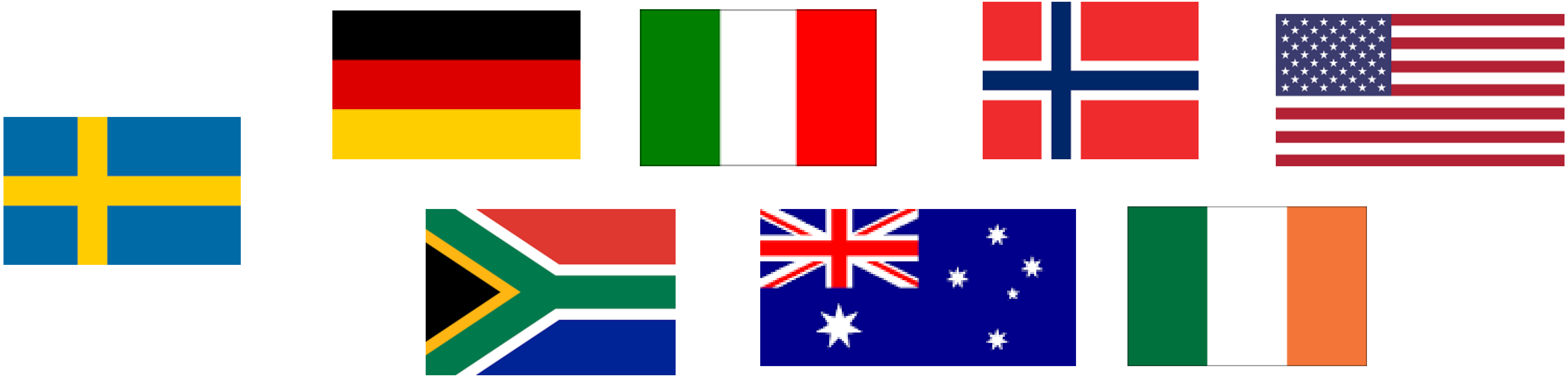
Outline

An overview of some of the work of Task 36 over the triennium: how circular economy and other emerging drivers are shifting the thinking regarding waste, energy, and resource recovery.

- The relevance of Circular Economy principles to Waste Management (and energy recovery)
- Technology implications
- New pathways and sectors

IEA Bioenergy Task 36

Material and energy valorisation of waste in a circular economy



http://task36.ieabioenergy.com/

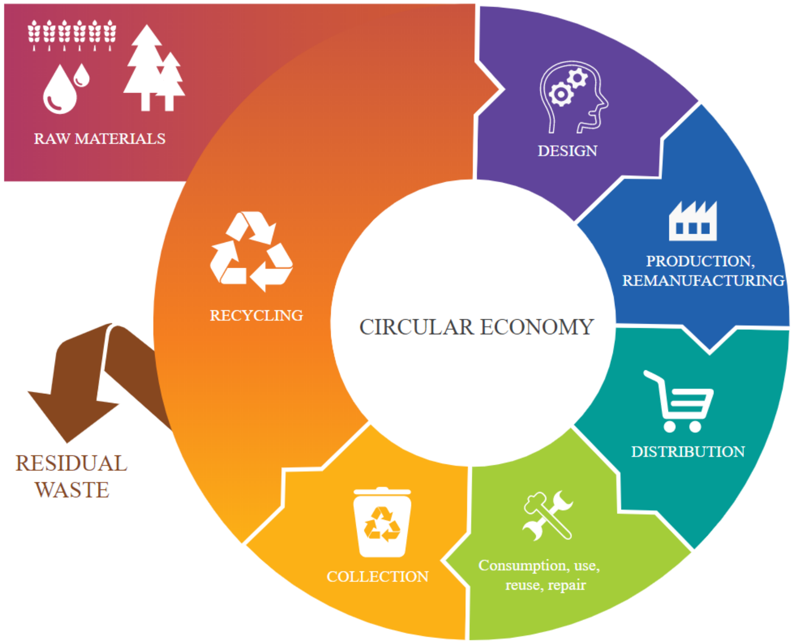
The Circular Economy

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.

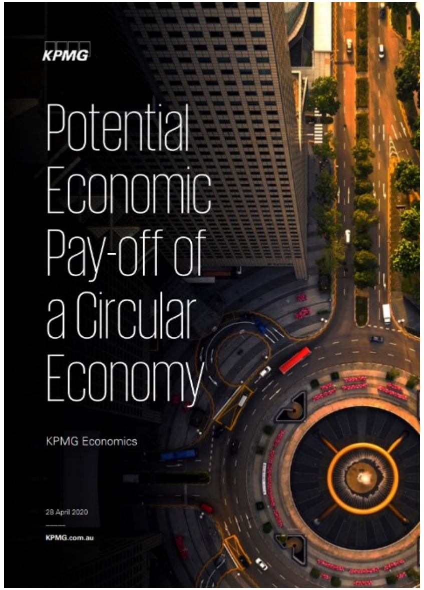
Aspects across manufacturing and supply chains – including the way we design and make things.

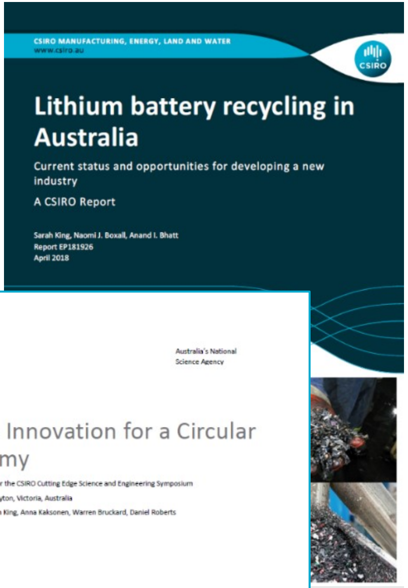


https://www.europarl.europa.eu/news/en/headlines/economy/20151201STO05603/circular-economy-definition-importance-and-benefits

The Circular Economy is broad

- Corporate strategies
- Government policies
- System development





Implications of CE for waste-to-energy:
Emerging trends

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

Getting more from current technologies

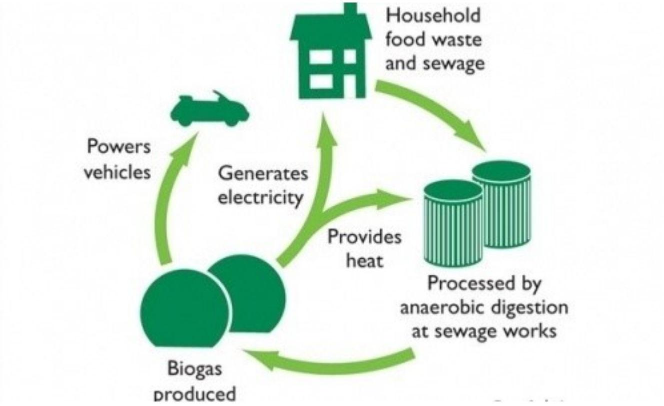
‘Traditional’ Waste-to-Energy

Combustion

- Heat and power, ash
- Effective source of renewable energy, often offsetting fossil energy, reducing waste to landfill.
- Still quite linear

Anaerobic Digestion

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



Increasing circularity

Fly ash valorisation

- Utilisation options
- Extraction
- Stabilisation

Process heat

- Moving from district heating to supplying industrial process heat

Nutrient recovery

- Phosphorous from wastewater treatment, ash
- Fertiliser applications from AD residues, biochar

BECCS

Not usually urban waste streams

- Usually woody biomass

Complex value chains

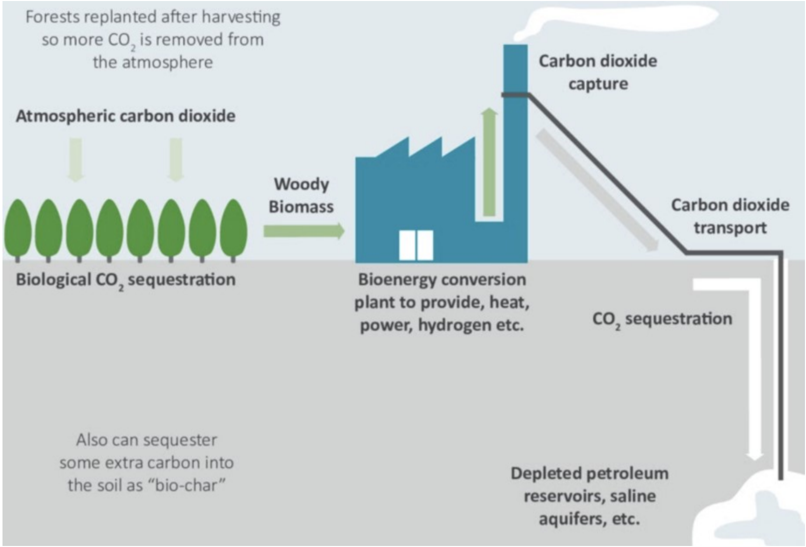
- With plenty of variables

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.

Implications of CE for waste-to-energy:

More than retrofitting.

Moving from …

- An inherently linear process
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  - Energy recovery, then
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To …

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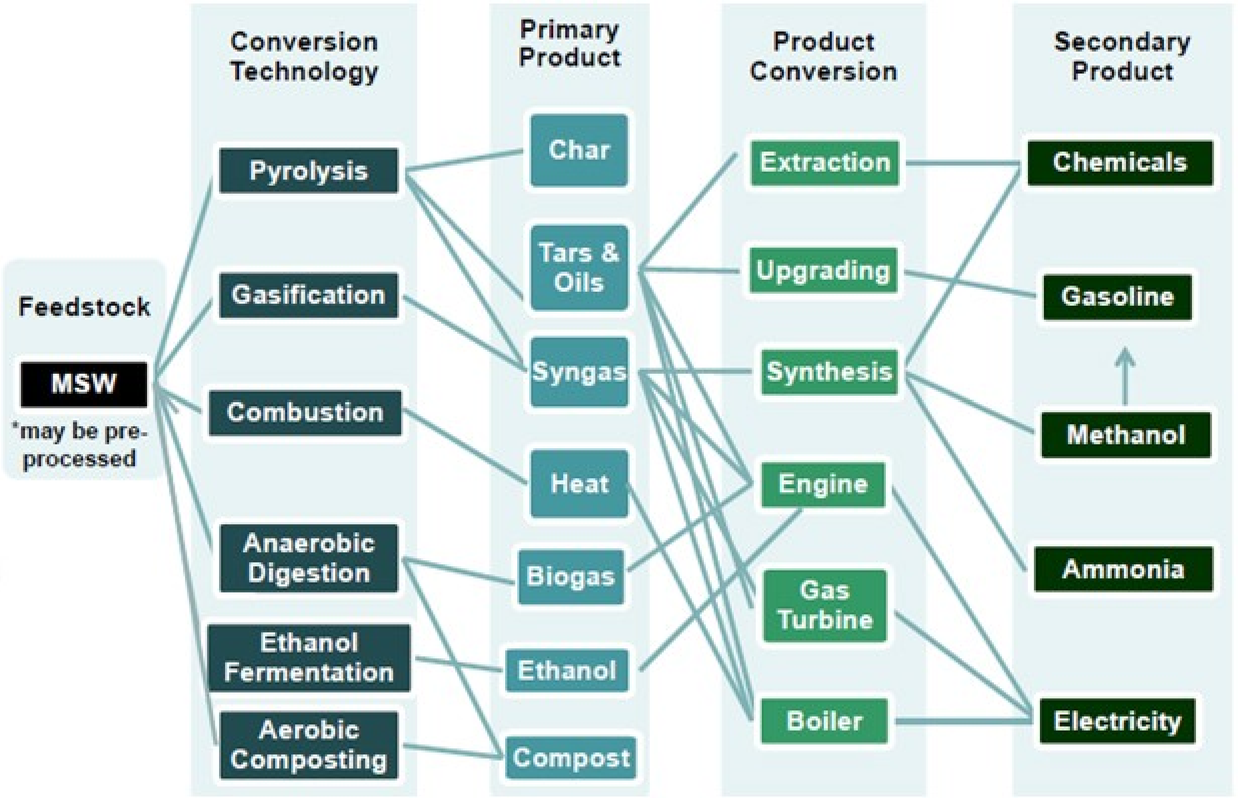
So … increased circularity needs new pathways

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.

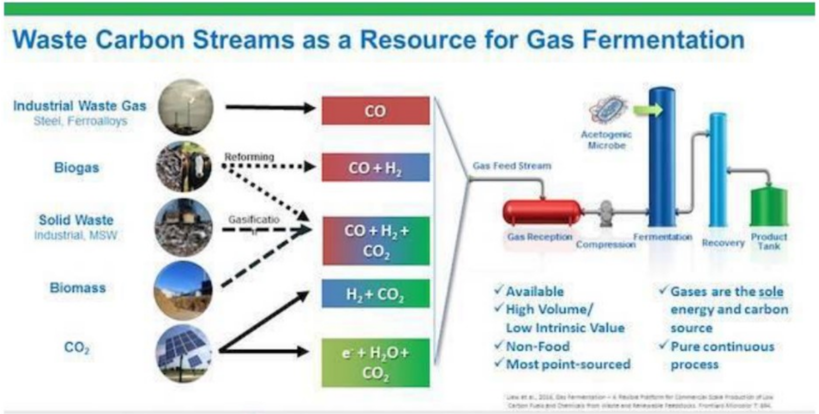
- Many concepts and demonstrations, and many with technical success
- Challenges with project economics
- Some technology-specific challenges with scaling up

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

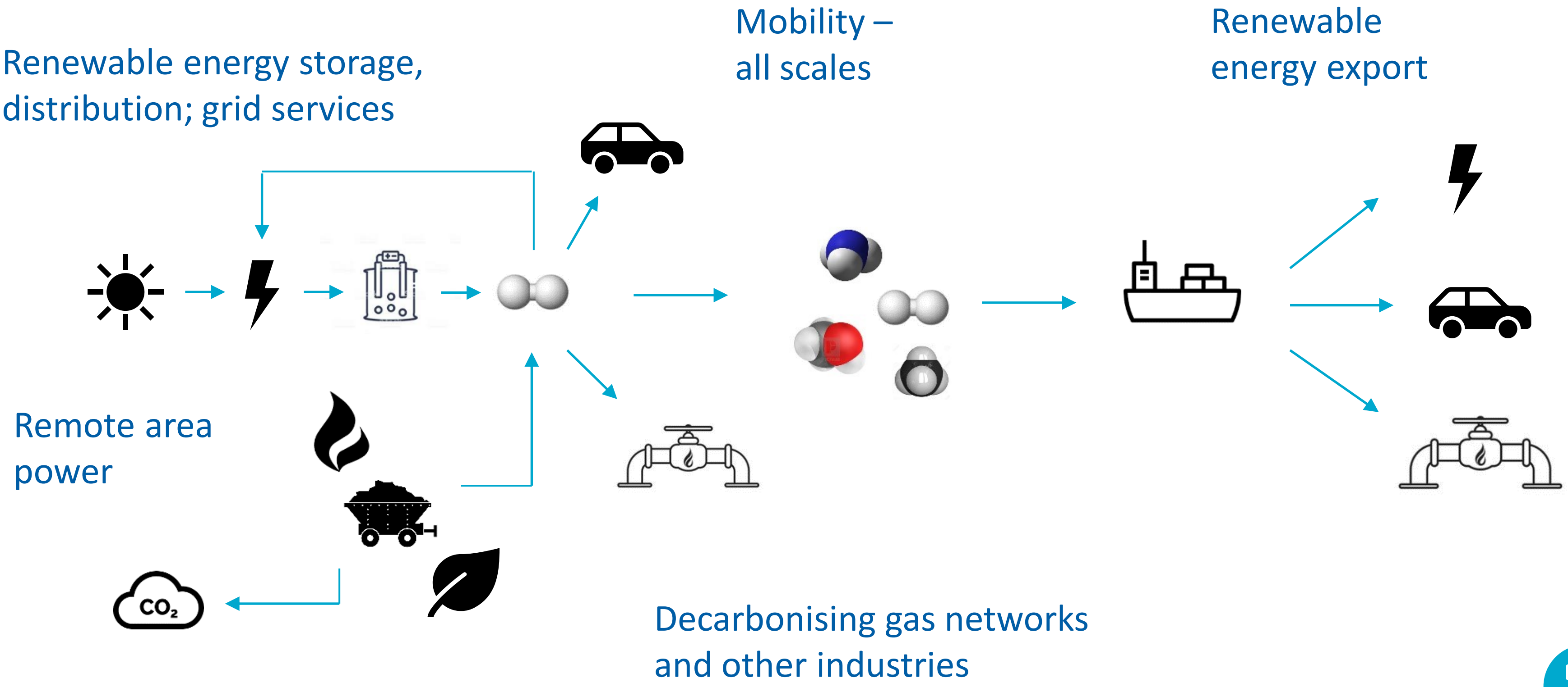
https://arena.gov.au/projects/logan-city-biosolids-gasification-project/

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/

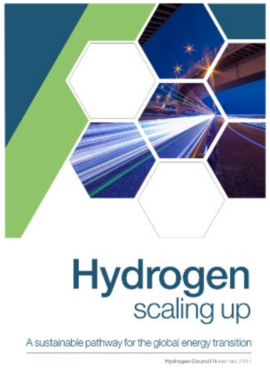
And hydrogen?

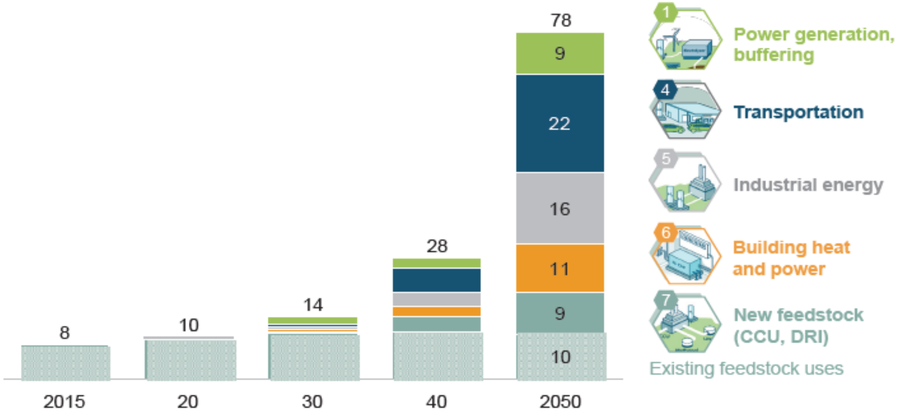


The challenge of scale

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 is a work in progress

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

CSIRO

Thank you

Dr Daniel Roberts
Research Program Director, Energy Technologies
CSIRO Energy

Daniel.Roberts@csiro.au | +61 7 3327 4521