Circular Economy, Energy Recovery from Waste, and Emerging Pathways

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Australia's National Science Agency

Outline

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

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

IEA Bioenergy Task 36

Material and energy valorisation of waste in a circular economy








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http://task36.ieabioenergy.com/

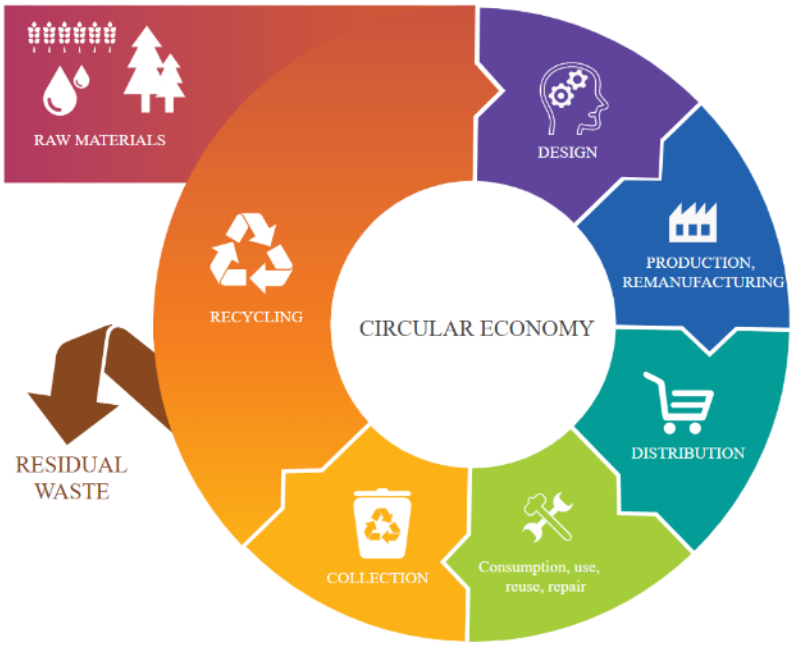
The Circular Economy

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

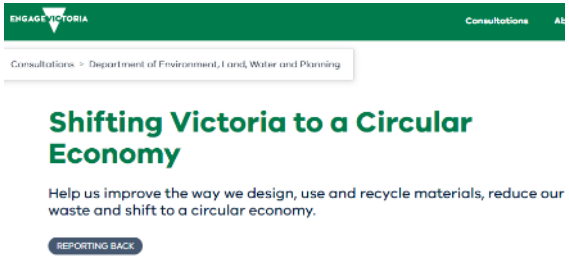
Wide in its reach

- Corporate strategies
- Government policies
- System development

Not limited to a single sector:

- Manufacturing
- Waste management
- Building and construction
- Power generation
- Agriculture
- …

https://www.monash.edu



https://engage.vic.gov.au/circulareconomy

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

Evolving existing pathways

‘Traditional’ Energy Recovery

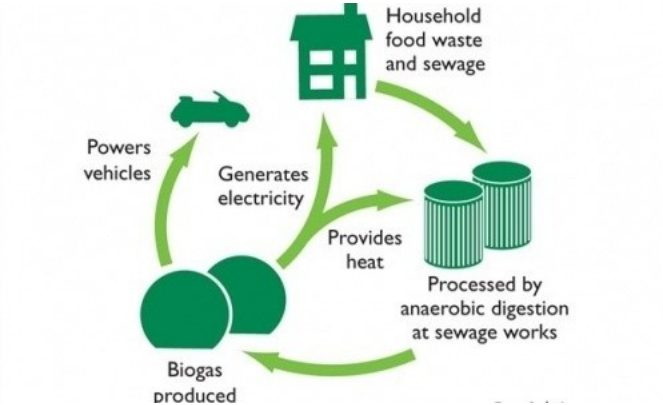
Combustion

- Heat and power, ash
- Still quite linear

Source: ARC website, Ehrhorn/Hummerston

Anaerobic Digestion

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



Fly Ash Valorisation

Hazardous nature of fly ash (and some other combustion residues) often sees them sent to landfill. CE principles are placing pressure on this approach.

State of the art

- Stabilisation, recovery of salts and metals.
- More recovery of salts and metals – full scale plants now emerging, legislative drivers are also now being put in place

Challenges

- Costs of retrofitting
- Extent of 'circularity'?

Offering	Organization
Ash2Salt®	Ragn-Sells
Fluwa/Flurec®	AIK Technik
Halosep®	Stena Recycling
Arcfume®	ScanArc
Fly ash washing and salts recovery	NOAH
Stabilisation and aggregate from fly ash	O.C.O Technology
Zn recovery	Renova and Chalmers University

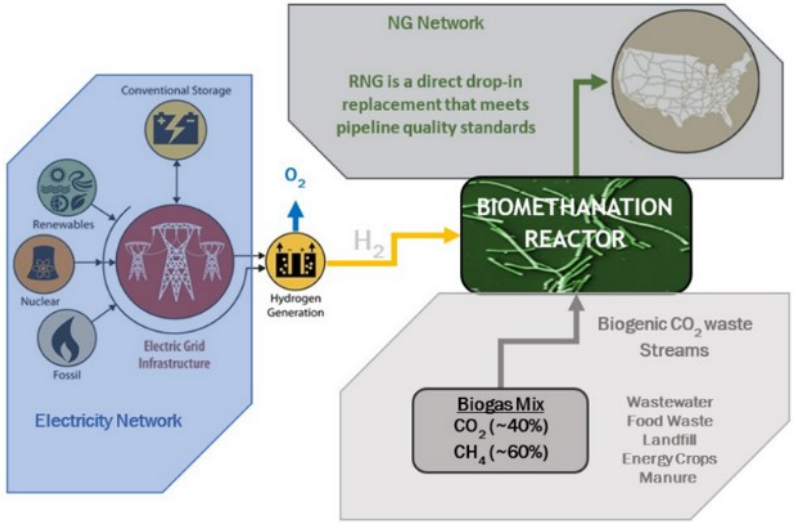
Technologies discussed at the Task's 'Fly Ash Valorisation' webinar:

https://task36.ieabioenergy.com/publications/webinar-valorisation-of-fly-ash-from-waste-to-energy/

Biomethanation

Biogas -> Biomethane

- Greater CH_4 yield via CO_2 conversion
- Builds on existing infrastructure
- Drop-in product.



Emerging pathways

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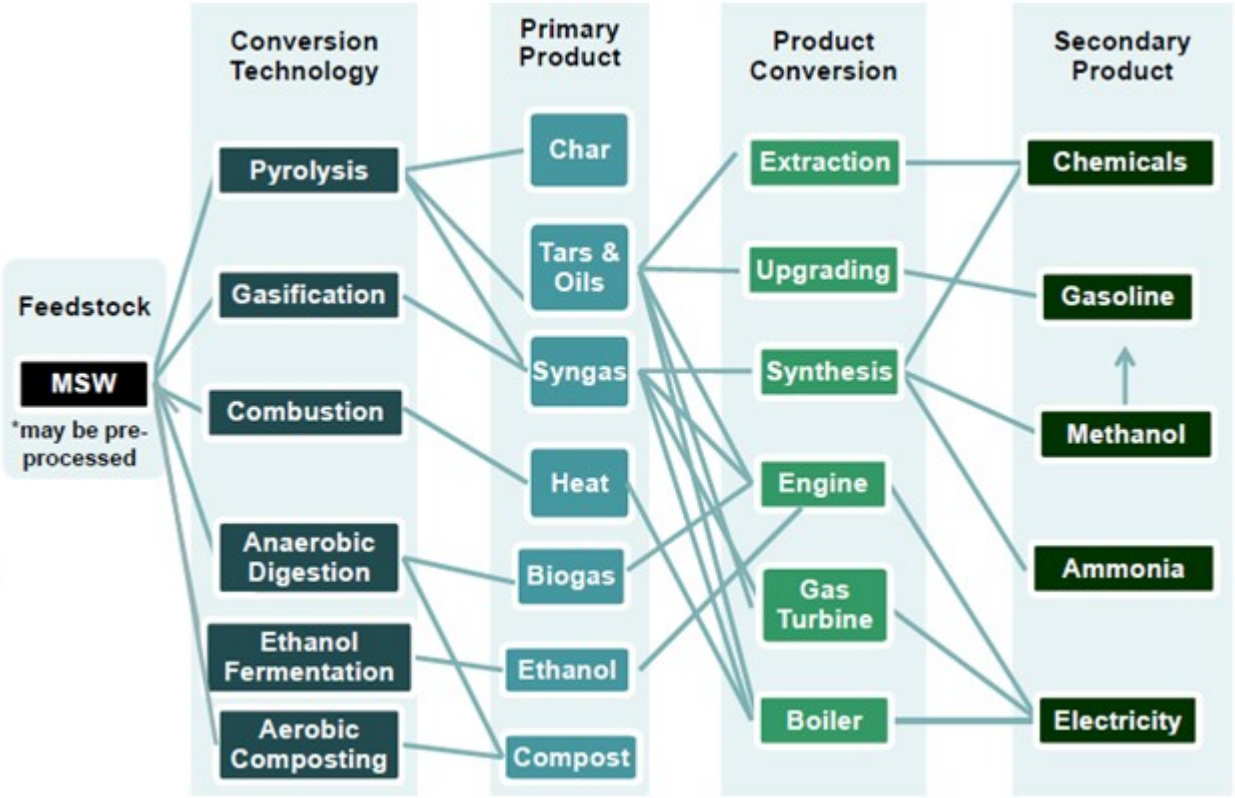
Which makes it complex:



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/

Other examples

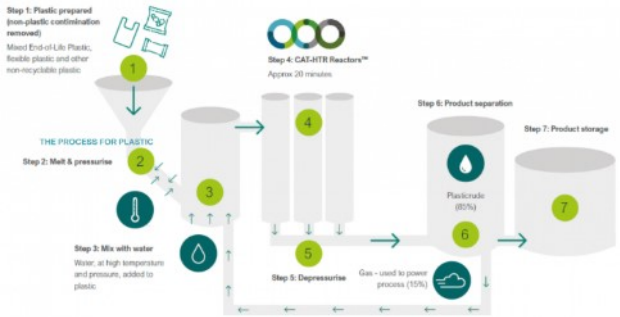
Pyrolysis

- 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/

Other examples

	Hunidity (%)	Volatiles (%)	Ashes (%)	Fixed coal (%)
Paper sludge	68,8	64,9	23,1	12
Ingelia Char	7,5	66,5	16,4	17,1

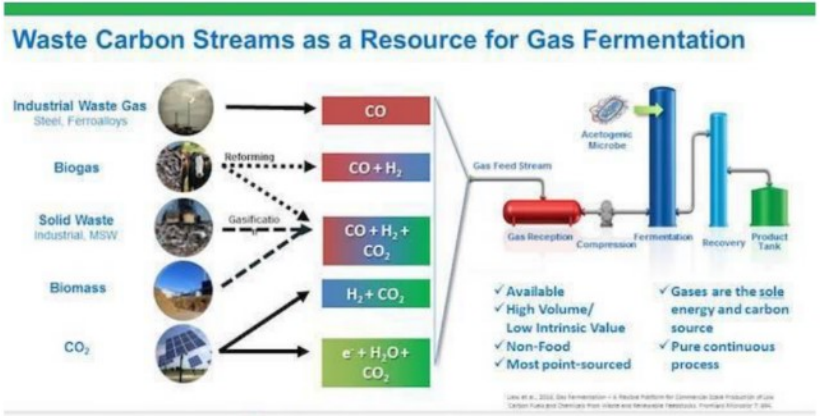
	C (% DAF)	S (% DAF)
Paper sludge	55,3	0,22
Ingelia Char	64,4	0,29

Hydrothermal carbonisation

- Lower T, higher P than torrefaction processes
- Stabilises materials for use as a feedstock in a range of processes.

Paper sludge -> hydrochar conversion using Ingelia technology (ref Task final report)

Product diversity (upcycling) with microbiology



https://www.lanzatech.com/

BECCS

Not strictly ‘waste’

- Usually woody biomass

Complex value chains

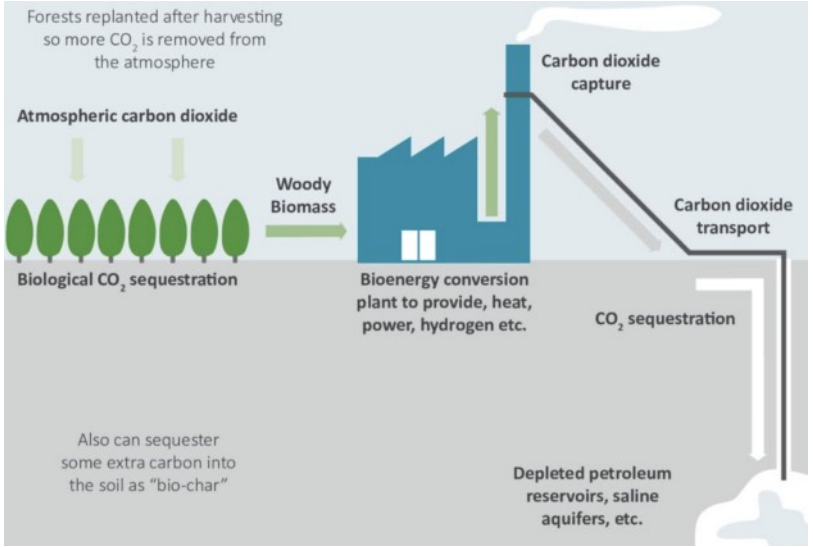
- With plenty of variables

Location, location, location

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

Expensive

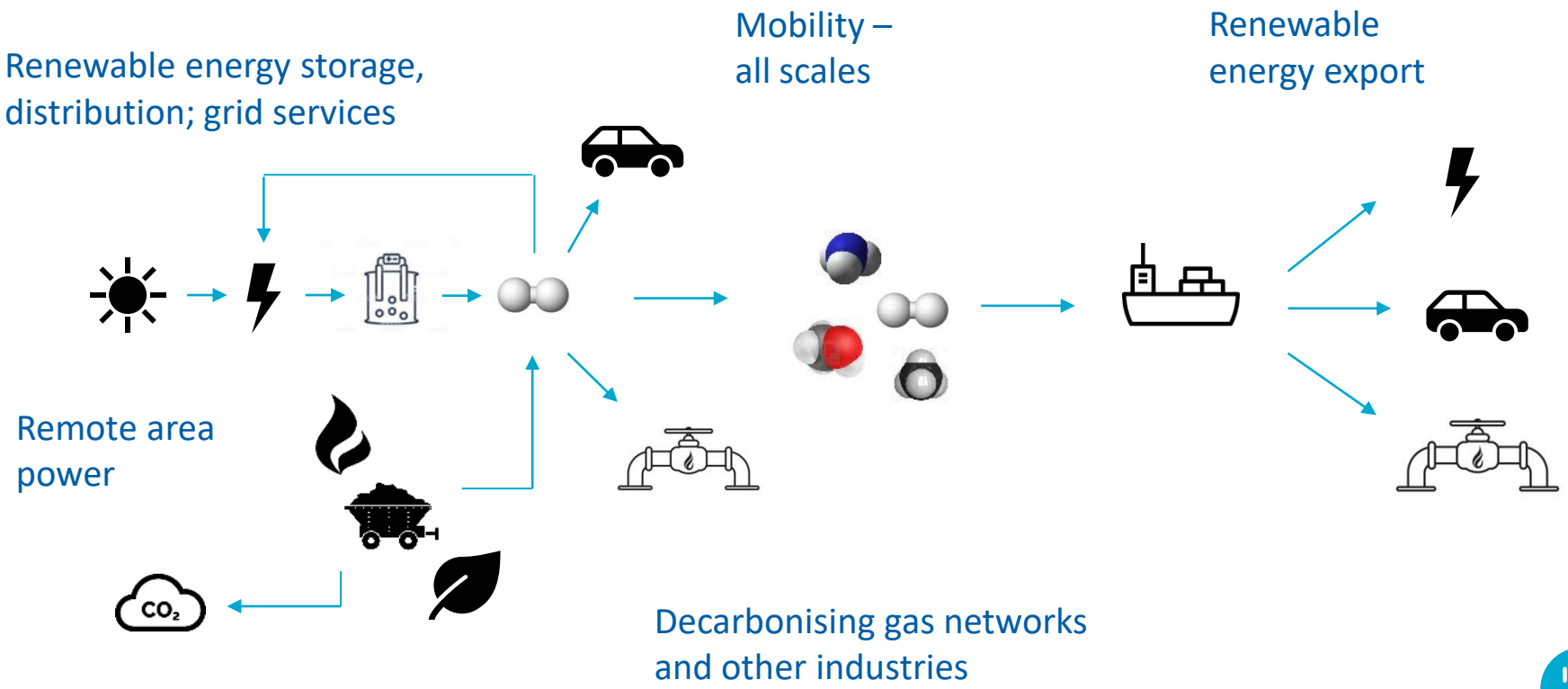
- Especially in a sector already troubled by cost of ‘next gen’.



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.

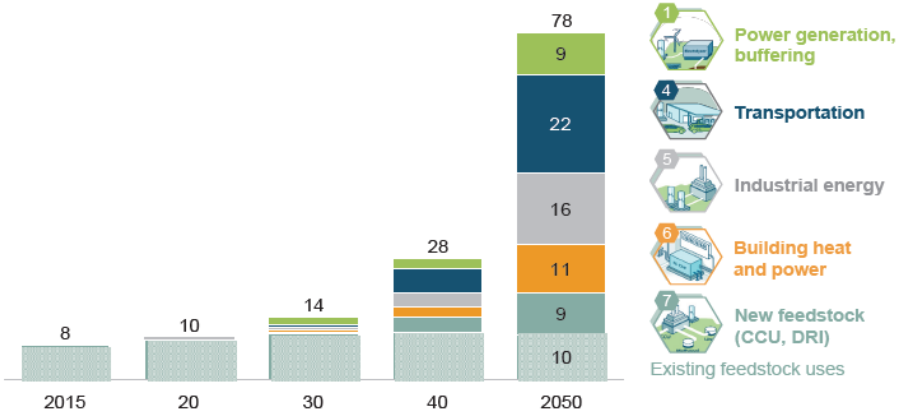
And hydrogen?

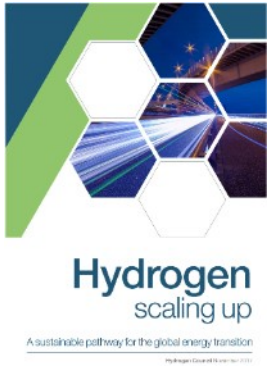


The challenge of scale

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?

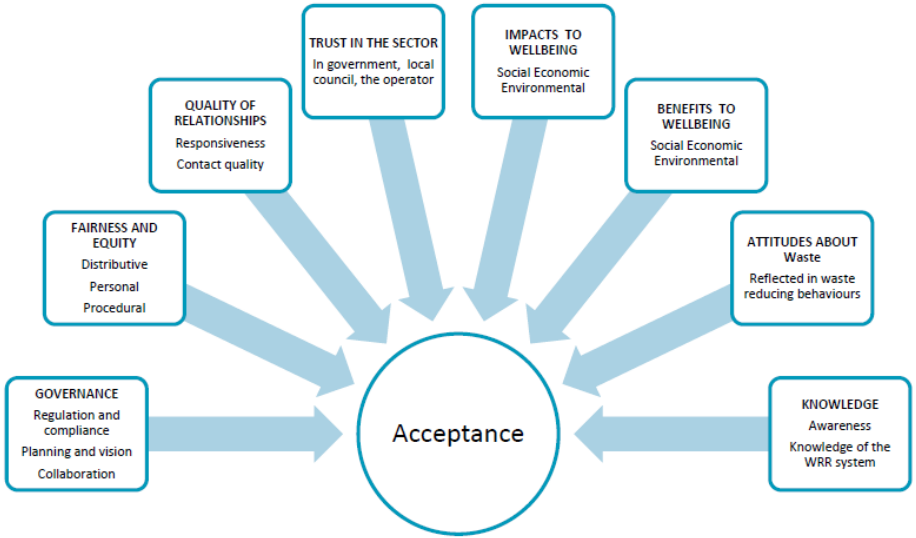
Emerging biological pathways

- Fermentative pathways
- Enzymes
- Bioelectrochemistry

→ Plenty of work still to do.

CSIRO

More than technologies …



Policy settings

Social acceptance

Actual environmental outcomes

Walton, A., McCrea, R., and Jeanneret, T. (2019). *Changes in Victorian attitudes and social acceptance in the waste and resource recovery sector: 2016 to 2019* CSIRO, Australia.

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 likely to be in the new pathways, rather than via retrofits.

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

More information

Visit the IEA Bioenergy Task 36 website:

https://task36.ieabioenergy.com/

For reports, newsletters, webinar recordings, case studies, etc.

Thank you

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