Circular economy challenges and opportunities in the energy transition

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Natural Environment Research Council

Resource Recovery from Waste

Department for Environment Food & Rural Affairs

Engineering and Physical Sciences Research Council

CATAPULT Offshore Renewable Energy

Zero Waste Scotland

Economic and Social Research Council

Department for International Trade

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Today

- Circular economy and energy
- Oil & gas decommissioning
- Offshore wind
- Supporting policy

Circular Economy

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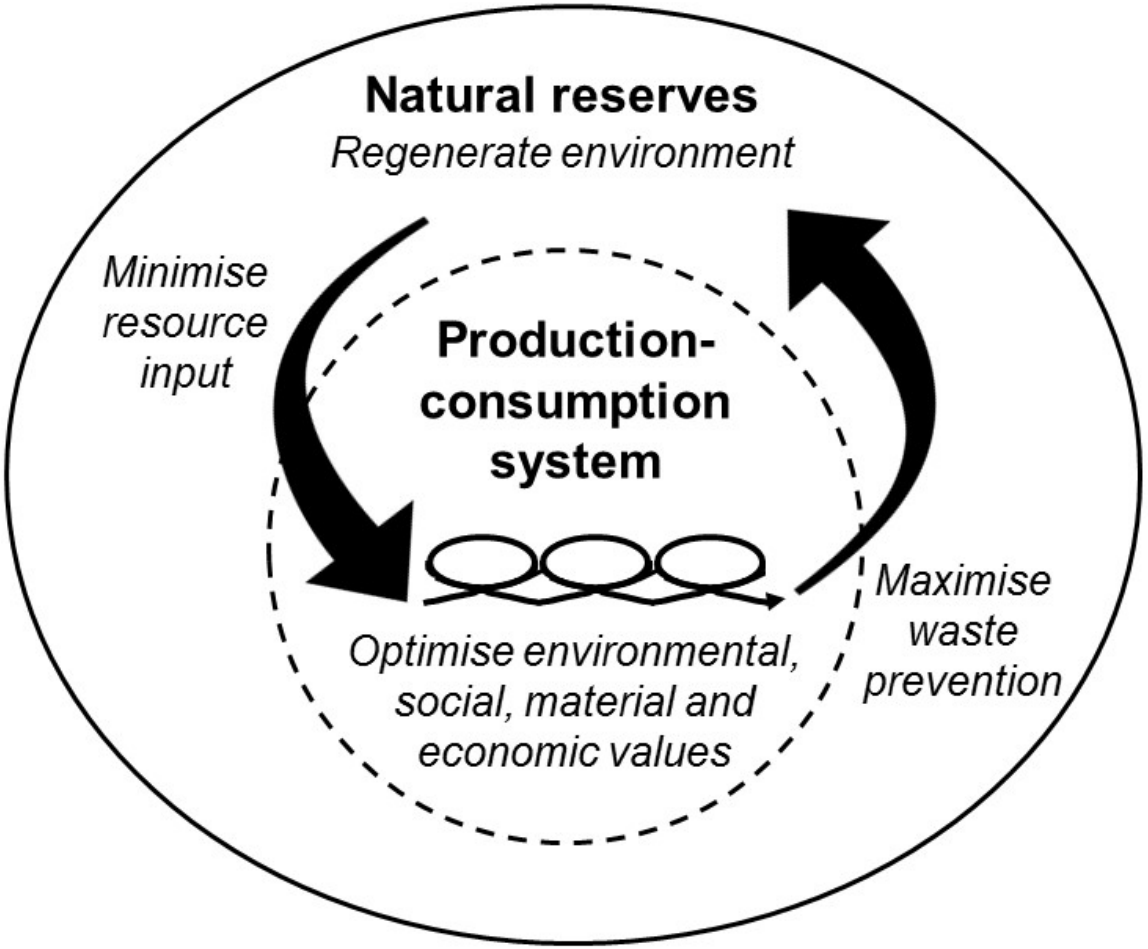

- Opposite of the linear take-make-use-dispose economy
- Make better use of materials, components and products
- Optimise economic, technical, social and environmental values of materials and products
- Whole lifecycle approach

Velenturf, A.P.M., Archer, S.A., Gomes, H., Christgen, B., Lag-Brotons, A.J., Purnell, P. (2019) *Circular Economy and the Matter of Integrated Resources.* Science of The Total Environment, Vol. 689: 963-969.

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Values of a Sustainable Circular Economy

Fair access to resources

Environmental quality

Economic prosperity

Velenturf and Purnell (2021) *Principles for a Sustainable Circular Economy.* Sustainable Production and Consumption, Vol. 27: 1437-1457.

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~~Values~~ Benefits of a Sustainable Circular Economy

Fair access to resources

+8M jobs in EU 2030

Environmental quality

-63% GHG globally 2050

Economic prosperity

+$25 trillion globally 2050

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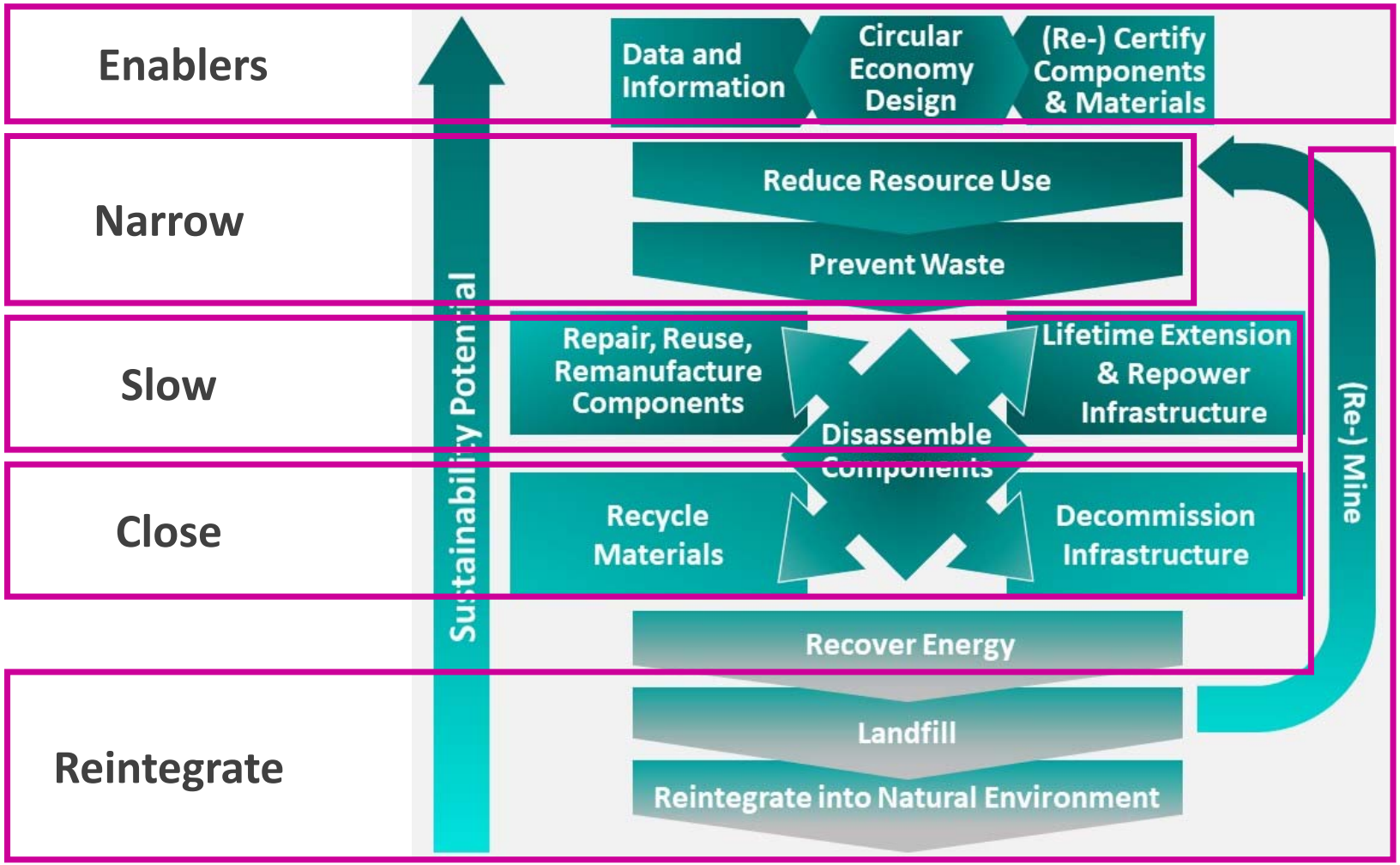
Circular economy strategies



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Jensen et al (2020) *Highlighting the Need to Embed Circular Economy in Low Carbon Infrastructure Decommissioning: The Case of Offshore Wind.* Sustainable Production and Consumption, Vol. 24: 266-280.

Velenturf et al (2021) Reducing material criticality through circular business models: Challenges in renewable energy. OneEarth, Vol. 4: 350-352.

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Recycling "circular" economy

Production and consumption patterns largely unchanged

Reformative

Technology will save us

Resource efficiency

Progress = Green growth

Weak sustainability

Sustainable circularity

Average material use per person halved

Transformative

Behaviour change

Resource efficiency + sufficiency

Progress = Well-being and environmental quality, with economic prosperity

Strong sustainability

Recycling ≠ Circular economy

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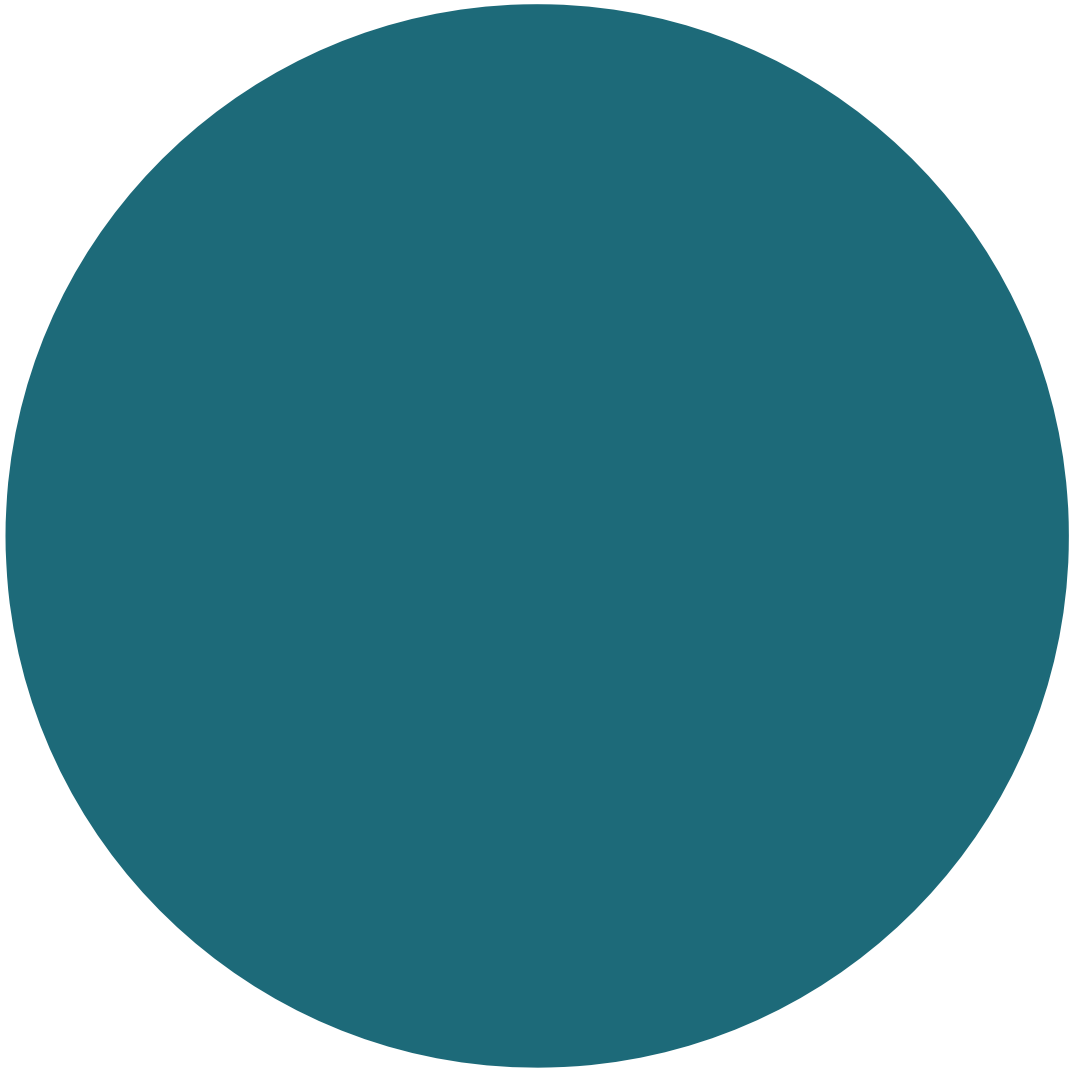

O’Neill et al (2018) A good life for all within planetary boundaries. Nature Sustainability, Vol. 1: 88-95

Opportunity in Energy Transition

Reduce Demand

Circular economy practices in UK North Sea oil & gas

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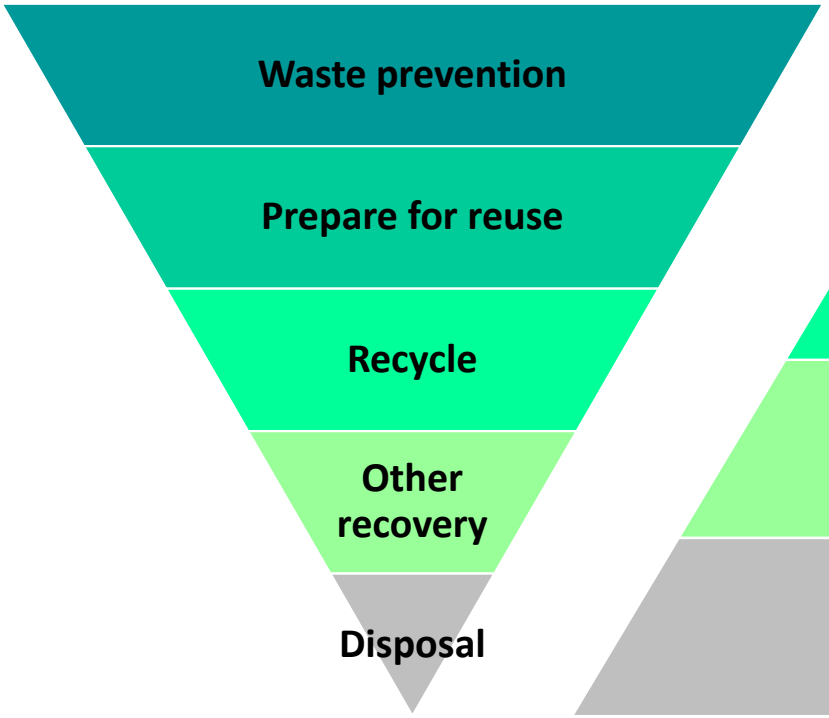
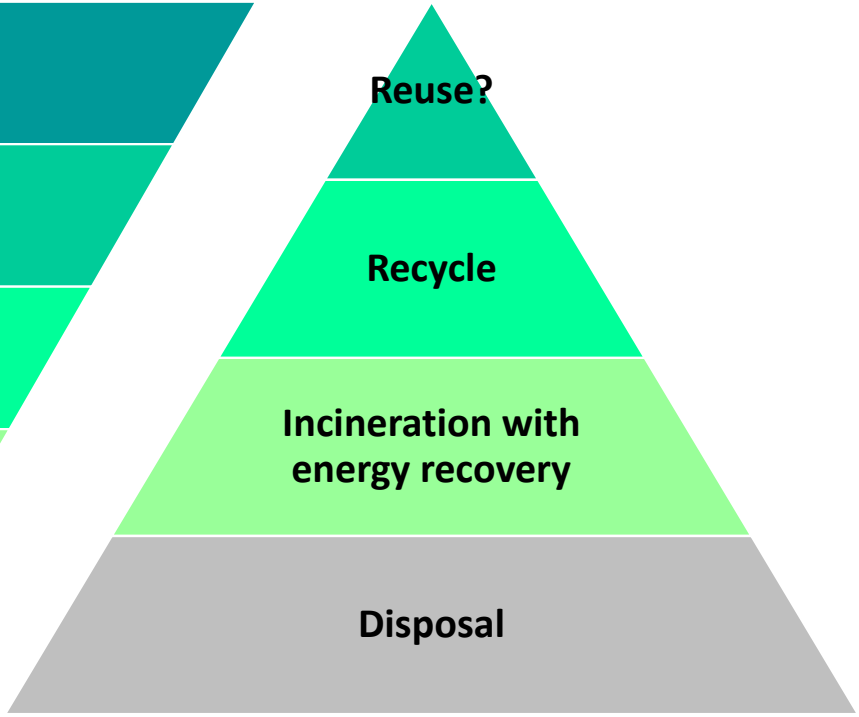
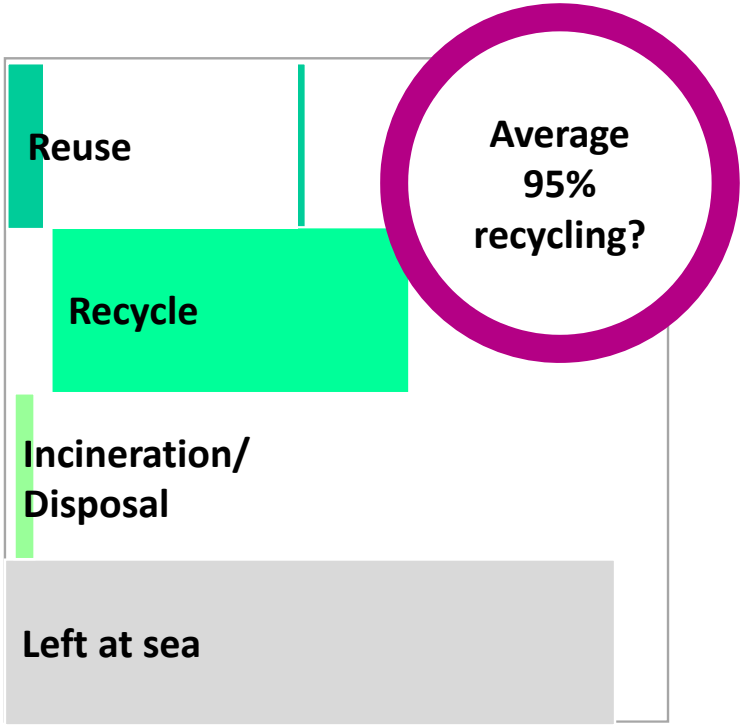


DEFRA waste hierarchy



BEIS decommissioning guidance?



What really happens?

Min/max recalculated from 4 close out reports.

Marques et al (2020) Reusing materials decommissioned from the North Sea: A systems perspective

What can be improved in North Sea oil & gas decom?

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Resources and energy governance not integrated, e.g. waste hierarchy not correctly applied

Current norm = No design to enable sustainable decom & circular economy

Developing local economy from strongly growing global decom market

Proactive decom planning with all relevant stakeholders involved incl. e.g. resources sector and new circular decom businesses

Higher regulatory ambitions to manage wastes in the UK

Exporting large volumes of waste to countries with poor health, safety and environmental regulations

Costs heavily under-estimated, better benchmarking approaches are available

Financial security mechanisms that don't cost the tax payer

Put the environment first, gain credibility by leaving monetary costs out of decom planning

Early investigation of potential reuse/ repurpose/ remanuf before end-of-use – prevent components becoming "waste"

Velenturf, A.P.M. (2020) Circular Oil & Gas Decommissioning.

What can be improved in N… oil & gas decom?

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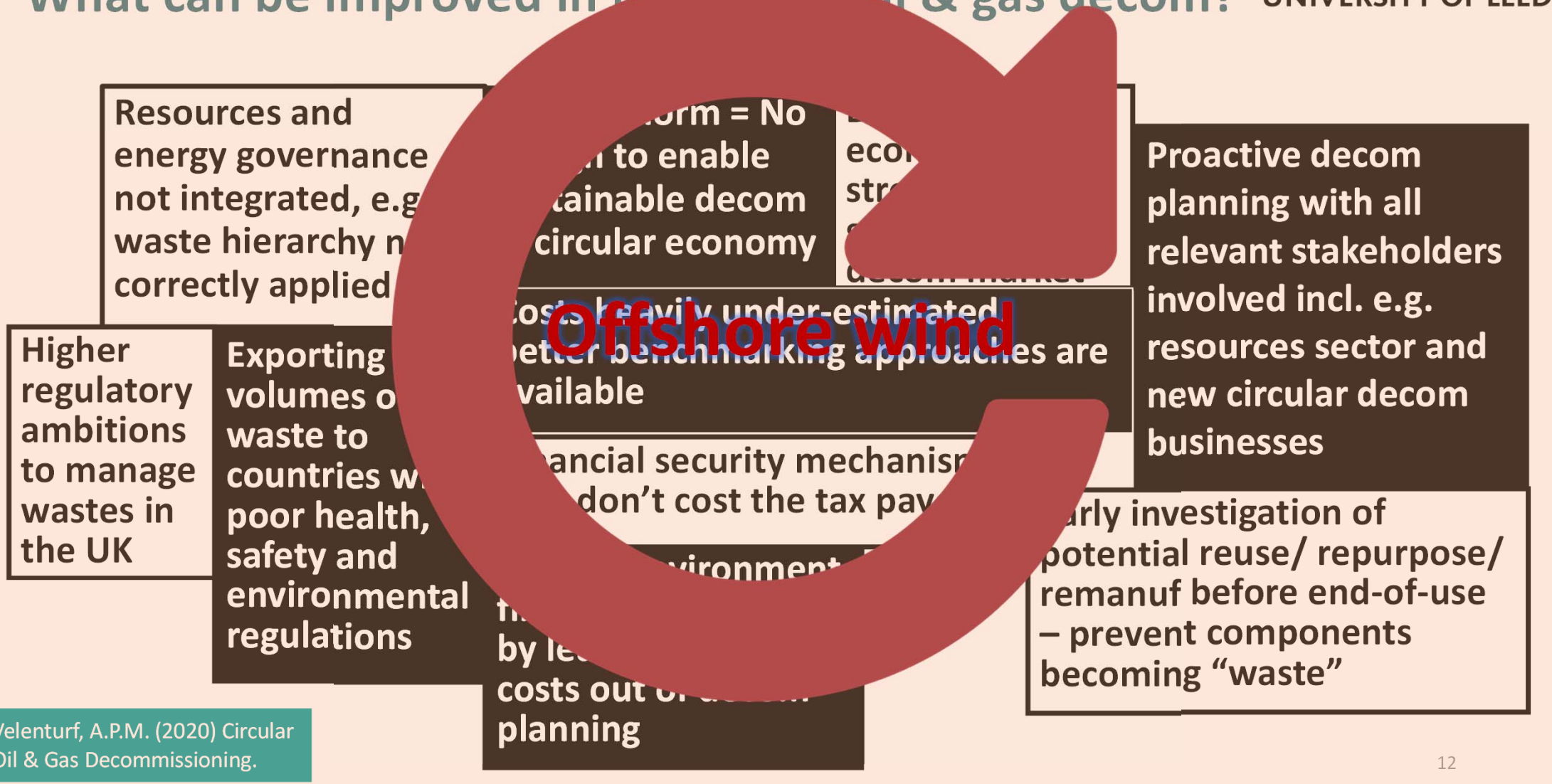

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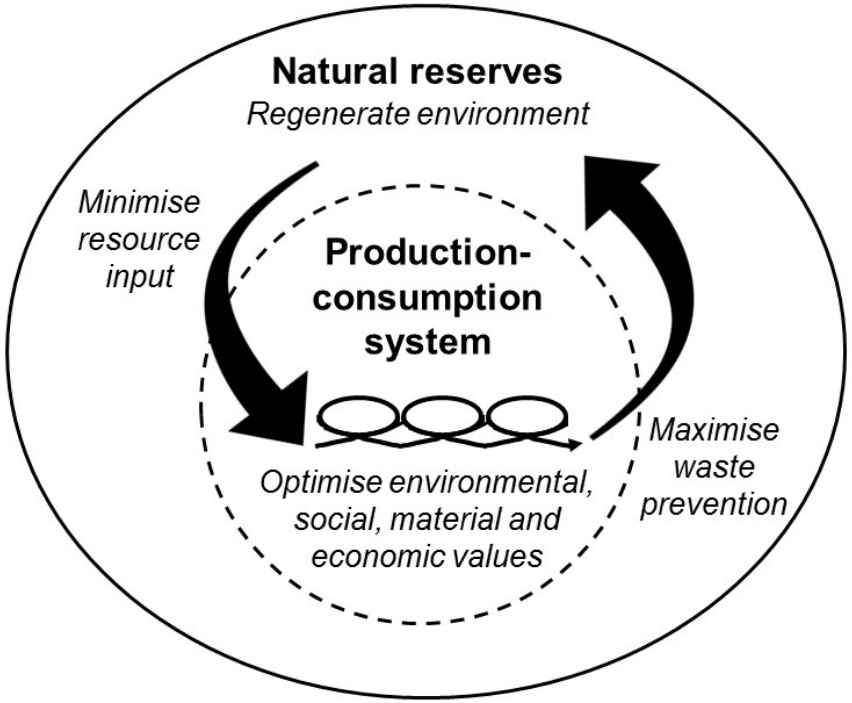

Circular economy

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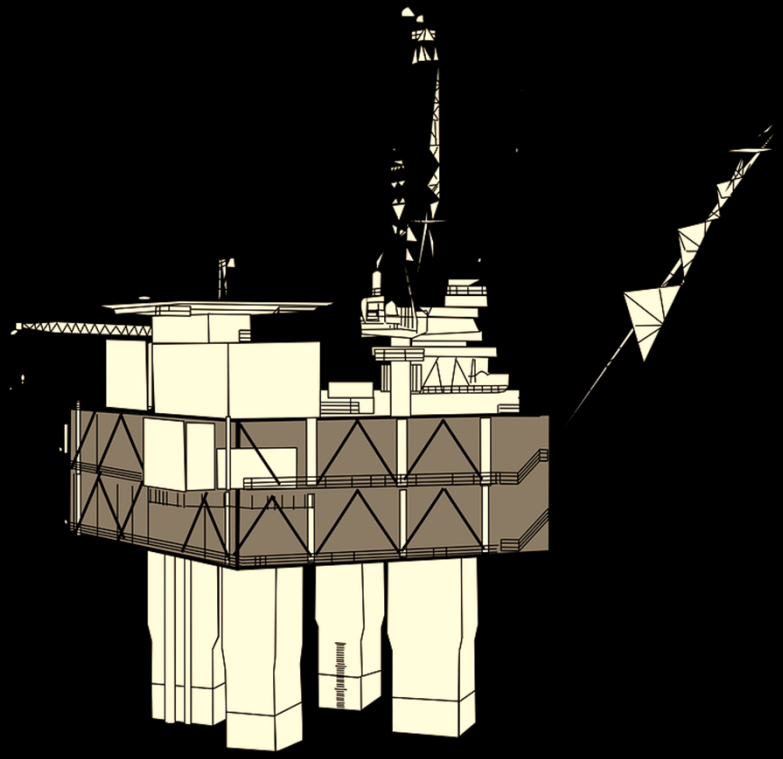
Fossil fuels



Design oil & gas infrastructure for energy transition

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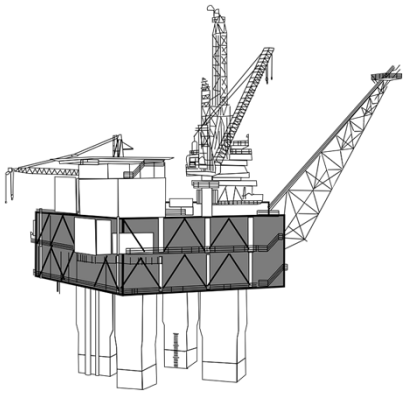

North Sea oil & gas
Design for repurposing for hydrogen, carbon capture and storage and integration with renewables.

Abolish MER UK strategy, crossing the policy divide with Clean Growth Strategy.

Adapt decommissioning guidance in line with circular economy.

Initiate **Just Transition plan** for fossil fuel workers.

Velenturf et al (2020) consultation response to the Oil & Gas Authority on the MER UK strategy.

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Interdependency renewables and fossil fuels

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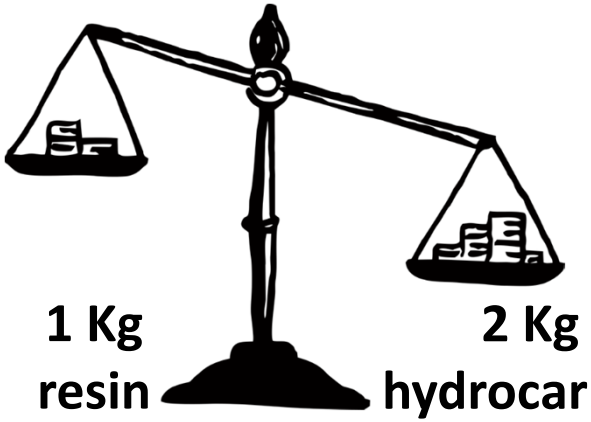
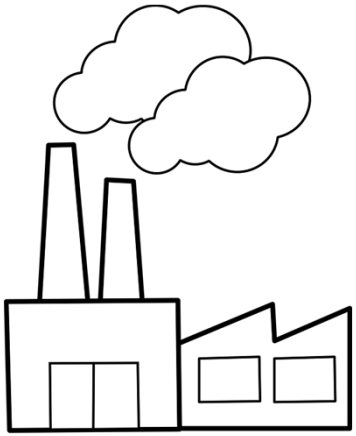
Materials



Glass fibre reinforced with resins

Energy



Machinery
High temperature processes

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Nearly all circular economy strategies are under-investigated in offshore wind

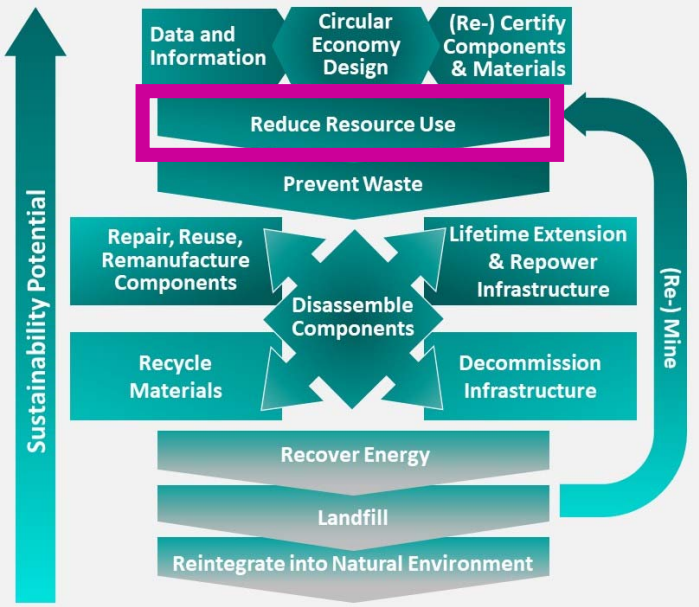
Dematerialisation

Reduced resource use through

- **Size optimisation**
- Shape optimisation
- Alternative materials

"a single larger turbine requires more resources than two smaller turbines, making the second case more environmentally friendly according to the material use requirements"

Topham et al (2019) Recycling offshore wind farms at decommissioning stage. Energy Policy, Vol. 129: 698-709.



Opportunity:

- Save costs by using less materials
- Reduce environmental impacts
- Greater social acceptance

Durability vs Recycling

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Challenges and opportunities:

- Resource exploitation and competition
- Stabilising turbine sizes, durable design

Example of **steel**

Metals biggest environmental impact

Steel monopile recycling:

2.2-2.4 improvement

Durable design steel+concrete monopile:

20.6-50.4 improvement

Bonus: less damage to turbine blades

Opportunity:

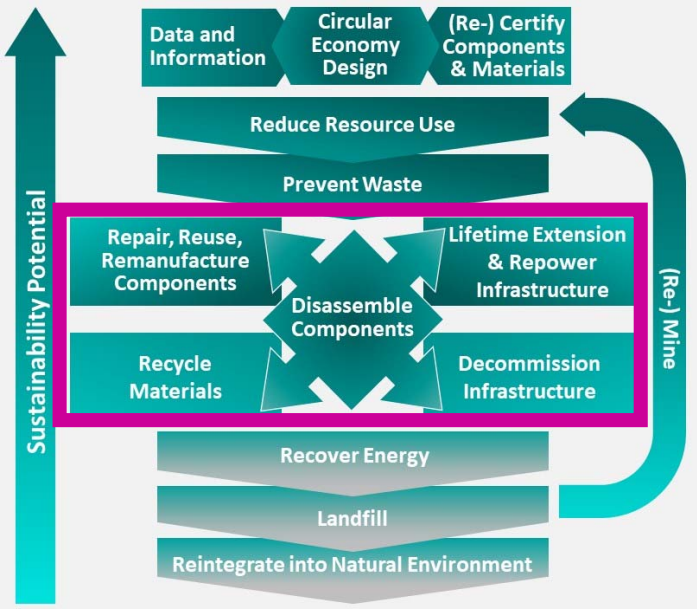
- New business models

  e.g. product service systems
- Save costs and reduce impact

  Site design for multiple lifecycle

Recycling:
85% steel
1-2% critical raw materials

Durability ca. 10-25x more benefit



Gallaghar et al (2019) Adapting stand-alone renewable energy technologies for the circular economy through eco-design and recycling. Journal of Industrial Ecology, Vol. 23 (1): 133-140.

Stamford and Azapagic (2012) Life cycle sustainability assessment of electricity options for the UK. Int. Journal of Energy Research, Vol. 36 (14): 1263-1290.

Making the business case for investment

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Business driven / Regulatory boundaries

Require insight into

Environmental

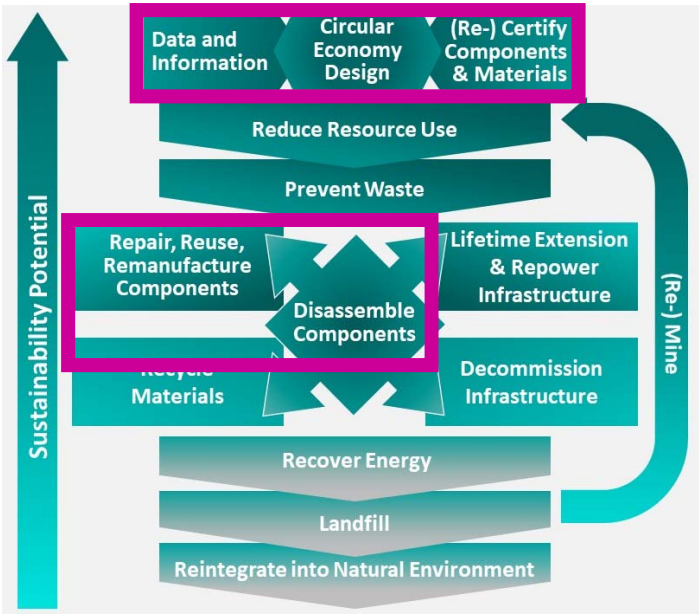
Social

Technical

Economic

Costs and benefits of circular economy strategies for stakeholders involved throughout the lifecycle of a wind farm

But: Clarify ownership structures and (legal) responsibilities



- ✓ Stronger implementation of waste legislation principles e.g. waste hierarchy, **EPR/IPR**
- ✓ Higher regulatory ambitions for component reuse, repurposing and remanufacturing
- ✓ Recertification schemes

Decommissioning programmes

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Challenges:

- Design for circular economy/ sustainable decommissioning is not the norm
- Poor quality decom plans
- Significant cost underestimates
- Financial ~~securities~~ insecurities

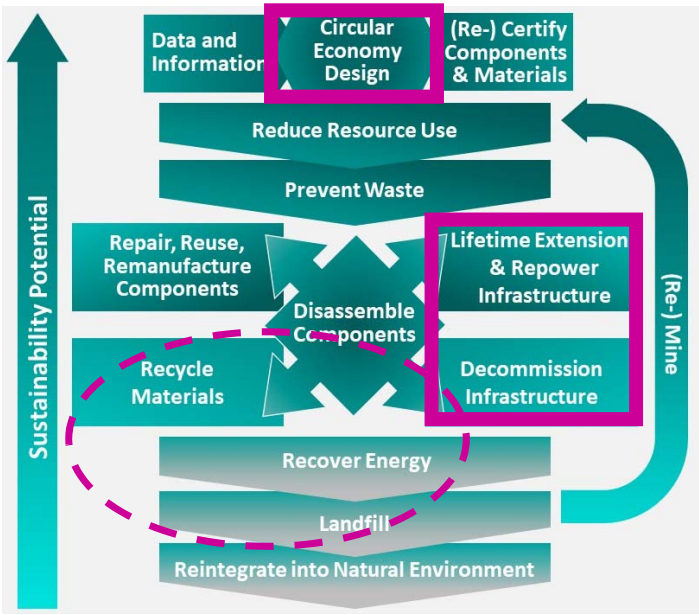
Solutions:

1. Update decommissioning guidance
2. Demand more complete costings and securities
3. Circular economy guidance offshore wind
4. Roadmap for circular solutions

Design: 3% SD 0.02% CE

0 Circular economy in decom plans

? Securities may be asked



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Mackie and Besco (2020) *Rethinking the Function of Financial Assurance for End-of-Life Obligations.* Environmental Law Reporter, Vol. 50(7): 10573-10603

Further reading

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Velenturf (2020) Challenges and opportunities for sustainable offshore wind development: Preliminary findings from a literature review and expert survey. Geoscience and The Energy Transition Sustainable Offshore Wind Development, University of Leeds.

University of Leeds (2020) Our low-carbon future needs to be circular.

Energy Leeds (2020) New research on circular economy and offshore wind" with links to introductory blogs, video and podcast.

Velenturf (2021) Circular Economy Business Opportunities in Offshore Wind: Workshop proceedings. Resource Recovery from Waste.
Summary in CIWM Knowledge Centre.

Roelich et al (2014) Assessing the dynamic material criticality of infrastructure transitions: A case of low carbon electricity. Applied Energy, Vol. 123: 378–386.

Jensen et al (2020) Highlighting the Need to Embed Circular Economy in Low Carbon Infrastructure Decommissioning: The Case of Offshore Wind. Sustainable Production and Consumption, Vol. 24: 266-280.

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