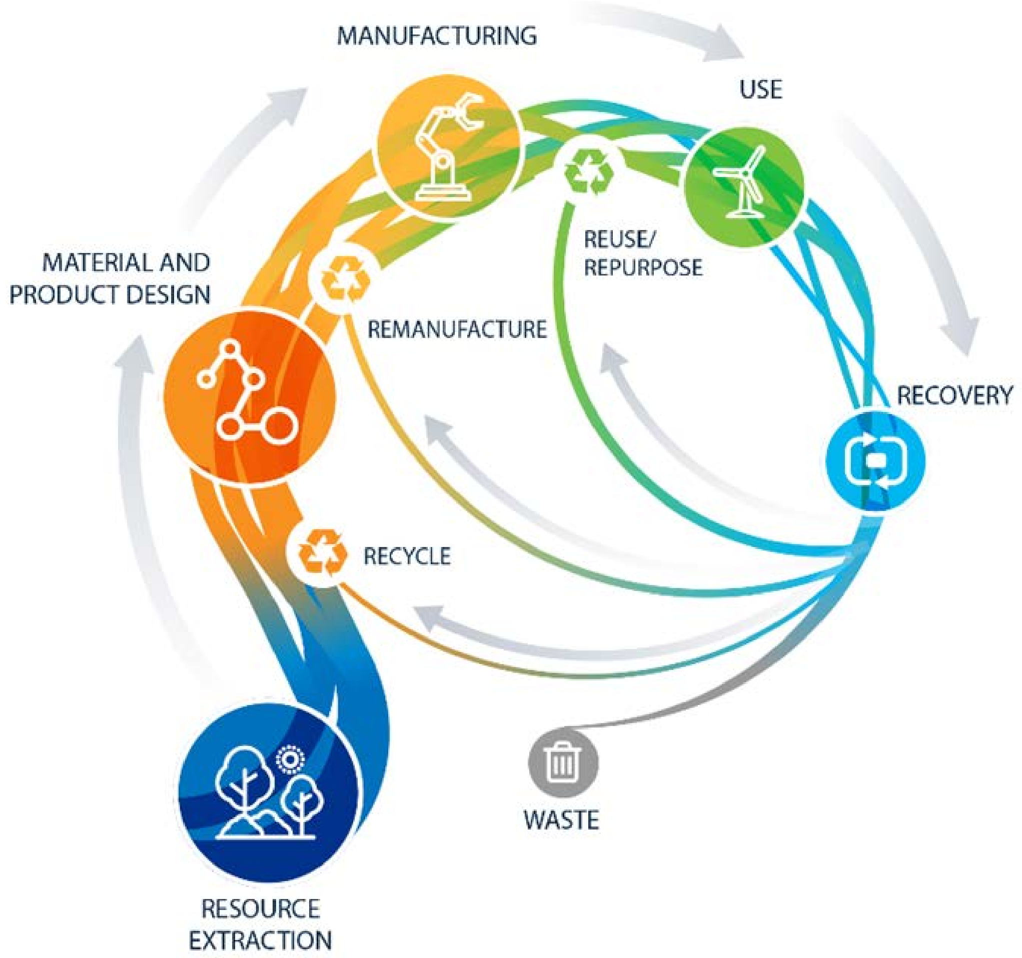
Can the circular economy move the needle on environmental and energy justice

Alberta Carpenter
RASEI Seminar
April 1, 2022



Outline

- What is the circular economy?
- What is environmental justice? What is energy justice?
- How do we implement it?
- Why do we care? What are the benefits?
- What are the challenges and research questions?
- How do we evaluate it?

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WHAT - In it's simplest and most ideal form

CE definitions

An industrial system that is **restorative or regenerative** by intention and design, replacing the end-of-life (EOL) concept with restoration, shifting to renewable energy, and eliminating toxic chemicals, which impair reuse. It aims to **eliminate waste** through the superior design of materials, products, systems, and related business models.
Kirchherr, Reike, and Hekkert (2017)

DRAFT ISO Standard: economic system that uses a systemic approach to maintain a **circular flow of resources**, by **regenerating, retaining or adding to their value**, while contributing to **sustainable** development

NREL definitions

NREL Strategy: Holistic approach to energy technologies that not only examines the near-term benefits of producing energy through renewable resources, but it also considers the **sustainability of the infrastructure** required for energy production with an emphasis on **responsible and effective use of natural resources (e.g., materials, land, water**).

Analysis perspective: Enable a clean energy transition by ensuring **resource sustainability** for a **decarbonized** and **resilient** U.S. energy economy. Developing clean energy technologies to be **reliable, durable**, and **equitable in their impacts** is critical.

CE Background

- Goal of CE
  - Keeping products, components and materials at their highest utility and value, at all times
  - Eliminating the concept of waste, with materials ultimately re-entering the economy at end of use in a valuable form
- Builds on some different schools of thought
  - Cradle to Cradle
  - Biomimicry
  - Performance Economy
  - Natural Capitalism
  - Industrial Ecology

CE & UN Sustainable Development Goals

- CE could directly contribute to SDGs 6, 7, 8, 12, 15 on water, energy, economic growth, responsible consumption & production, and life on land respectively
- CE could also support SDGs 1, 2, 11, 14 (no poverty, zero hunger, sustainable cities & communities, and life below water)

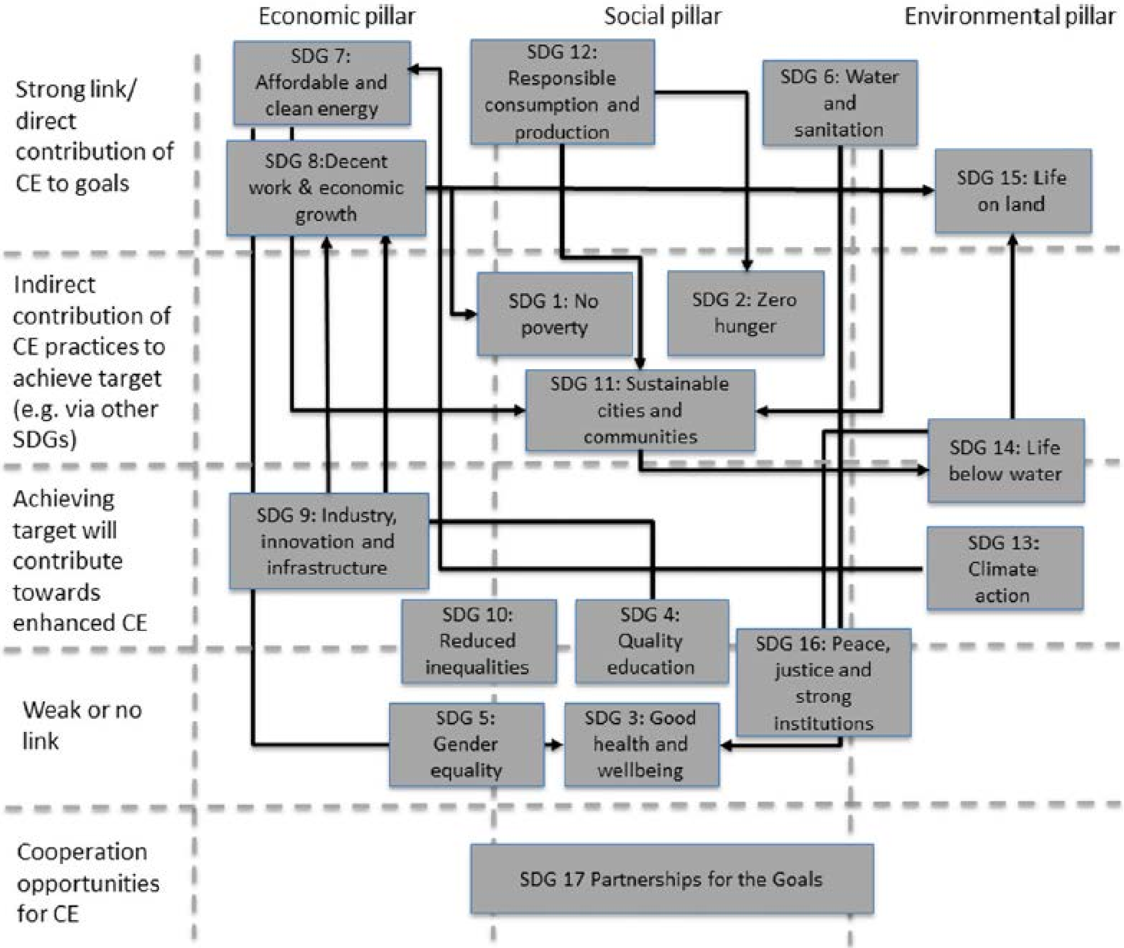
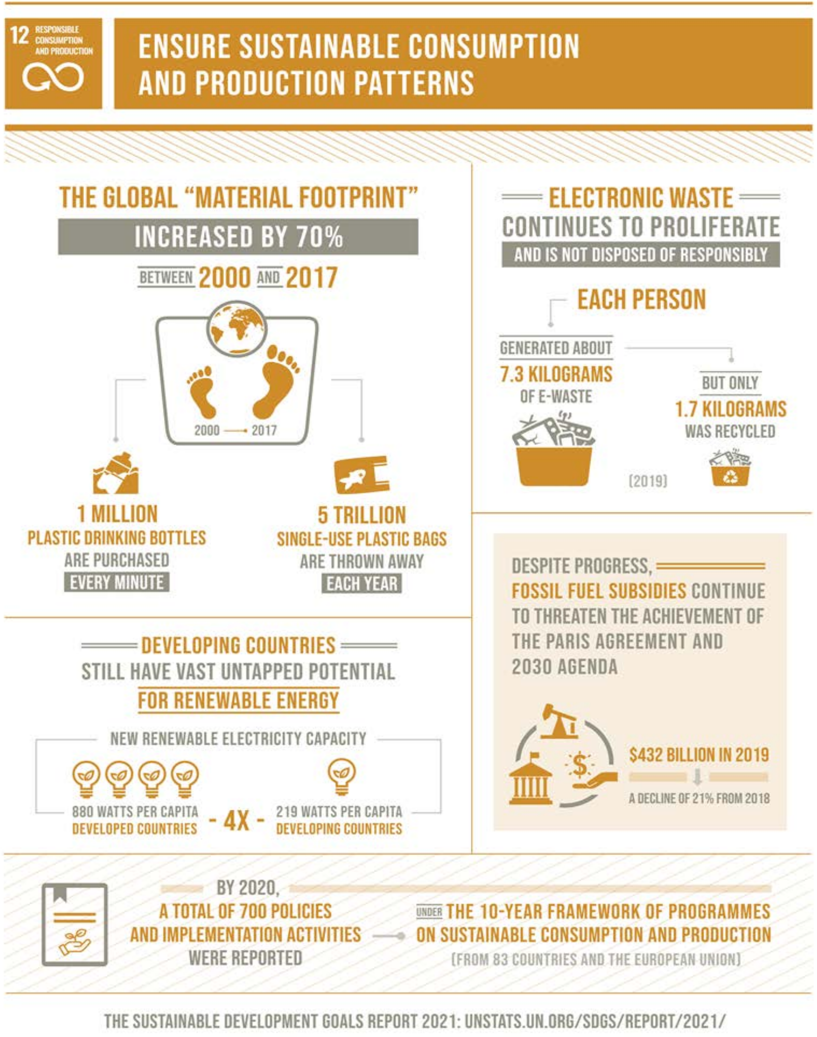


Image source: Schroeder, P., Anggraeni, K., & Weber, U. (2019). The Relevance of Circular Economy Practices to the Sustainable Development Goals. Journal of Industrial Ecology, 23(1), 77-95. doi:https://doi.org/10.1111/jiec.12732

UN SDG #12

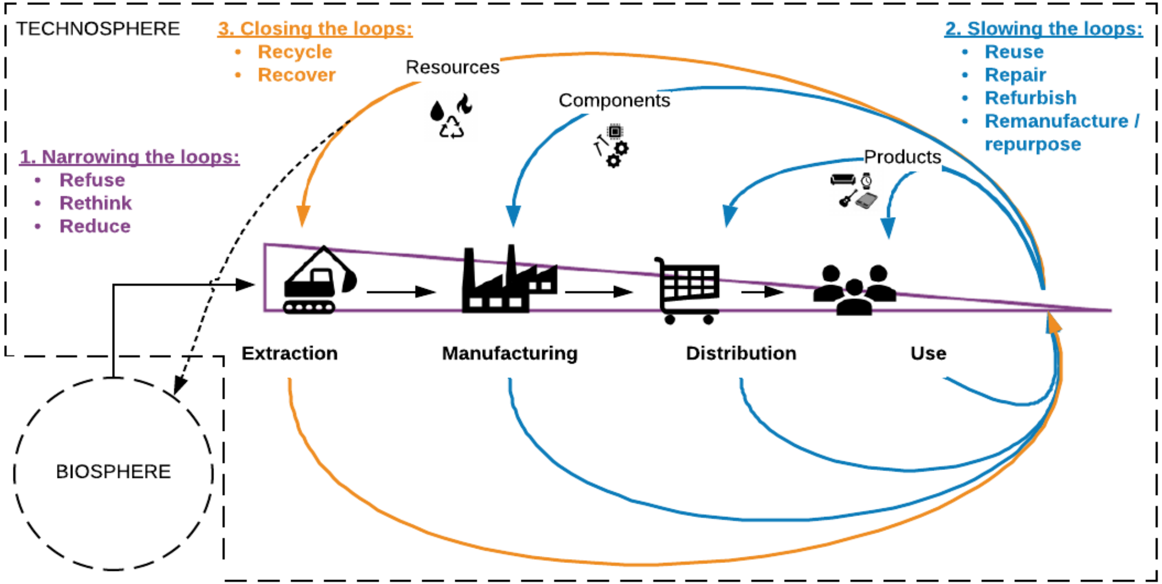
- UN Sustainable Development Goal #12 – Ensure sustainable consumption and production patterns. Example of contributions to SDG 12:
  - 12.2 achieve sustainable management and efficient use of natural resources
  - 12.3 halve per capita global food waste
  - 12.5: reduce waste generation through prevention, reduction, recycling and reuse



Background

- **Problem:** In the next decades demand for raw materials is expected to increase (e.g., 3000% for photovoltaics (PV) between 2015 and 2060 (Sovacool, 2020))
  - 100 billion metric tonnes of materials consumed each year, 177 billion by 2050 (Circle Economy, 2021)
  - Increases the risk posed by sudden supply restrictions (Schrijvers et al., 2020)
  - Contributes to global GHG emissions due to their embodied energy (Circle Economy, 2021): cradle-to-gate materials are responsible of 18% of global GHG emissions (Hertwich, 2019)

- **A solution?** The circular economy (CE) spurs material efficiency e.g., through reusing/recycling products and transforms waste to wealth by:
  - Narrowing flows (use less): refuse, rethink, reduce
  - Slowing flows (use longer): reuse, repair, refurbish, remanufacture /repurpose
  - Cycling flows (use again): recycle, recover

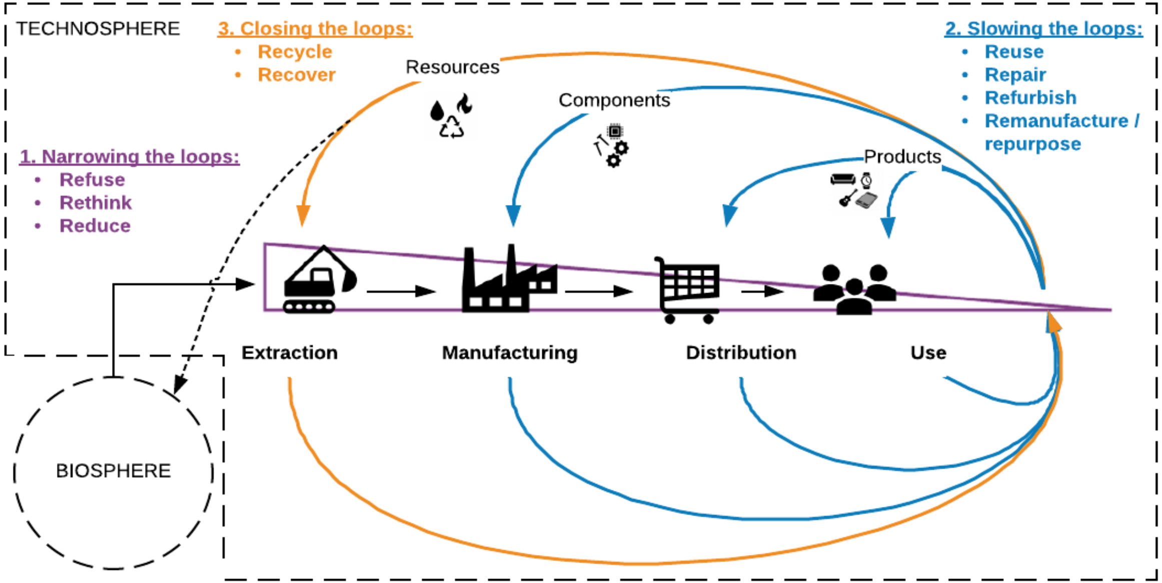


Covers a lot of territory

Preserve and enhance natural capital by controlling finite stocks and balancing renewable resource flows

Optimize resource yields by circulating products, components and materials in use at the highest utility at all times

Foster system effectiveness by revealing and designing out negative externalities



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Environmental justice definition

Environmental justice (https://www.epa.gov/environmentaljustice**)** is the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. This goal will be achieved when everyone enjoys:

- The **same degree of protection from environmental and health hazards**, and
- Equal access to the decision-making process to have **a healthy environment in which to live, learn, and work.**

Energy justice definition

- “The goal of energy justice (or energy equity) is to achieve equity in **both the social and economic participation in the energy system**, while also **remediating social, economic, and health burdens on those historically harmed by the energy system**,” (Initiative for Energy Justice).
- **A lack of access to modern energy contributes to chronic or persistent poverty**. Thus, energy inequalities often find a reflection in income inequalities, gender inequalities and inequalities in other developmental dimensions. Community amenities and services also suffer from a lack of adequate access to modern energy. (https://previous.iiasa.ac.at/web/home/research/alg/energy-inequality.html)
- NREL's vision for a clean energy future focuses on sustainable solutions that enable **all people to benefit from the energy transition**; advances prosperity, security, and **energy resilience for all**; addresses the social, economic, and health **burdens placed on some communities from our energy system.**

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Circular Economy Strategies (Rx)

Circular economy

Increasing circularity

Rule of thumb: Higher level of circularity = fewer natural resources and less environmental pressure

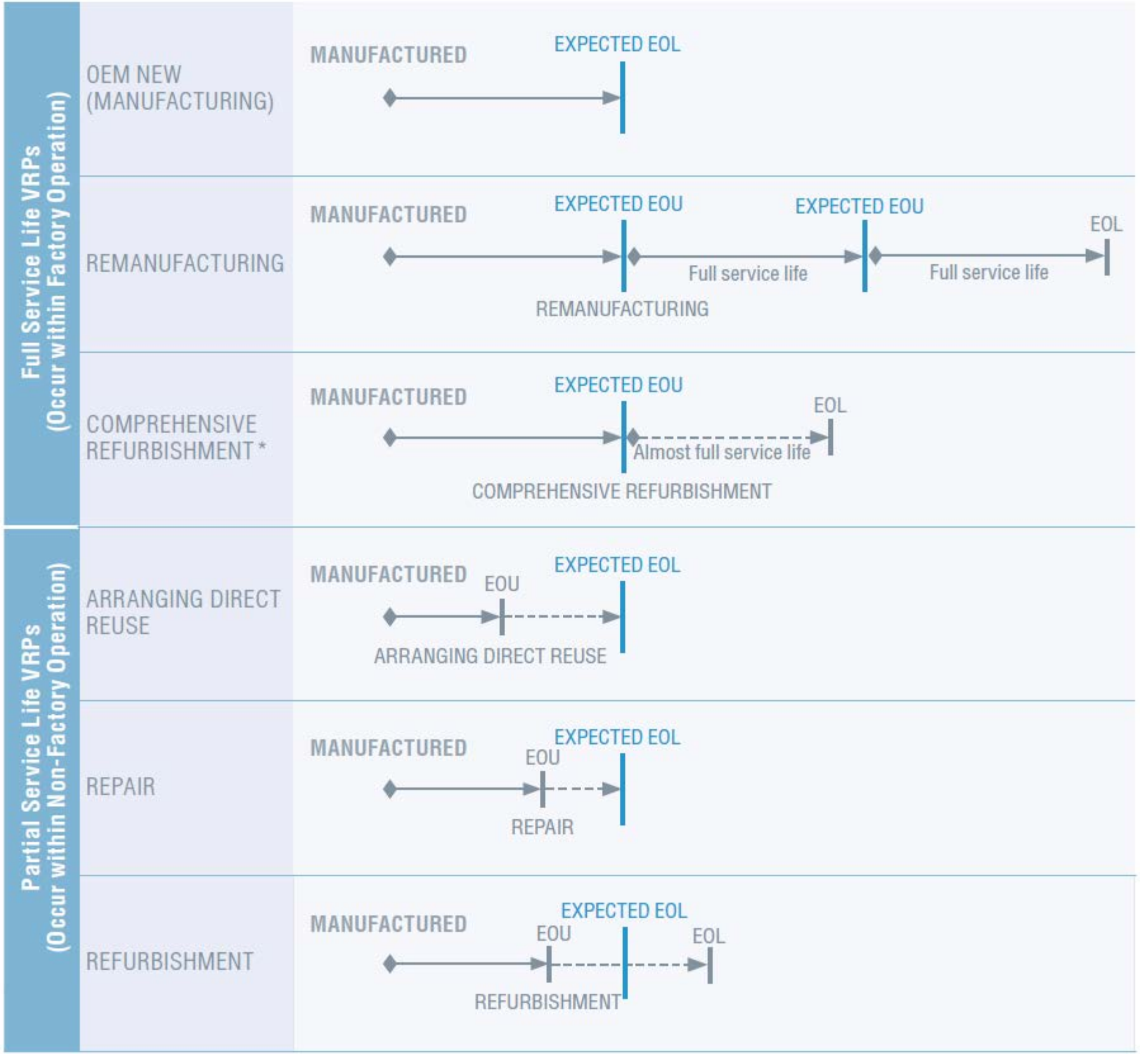
Linear economy

Circular economy	Strategies		
Smarter product use and manufacture	R0	Refuse	Make product redundant by abandoning its function or by offering the same function with a radically different product
	R1	Rethink	Make product use more intensive (e.g. through sharing products, or by putting multi-functional products on the market)
	R2	Reduce	Increase efficiency in product manufacture or use by consuming fewer natural resources and materials
Extend lifespan of product and its parts	R3	Re-use	Re-use by another consumer of discarded product which is still in good condition and fulfils its original function
	R4	Repair	Repair and maintenance of defective product so it can be used with its original function
	R5	Refurbish	Restore an old product and bring it up to date
	R6	Remanufacture	Use parts of discarded product in a new product with the same function
	R7	Repurpose	Use discarded product or its parts in a new product with a different function
Useful application of materials	R8	Recycle	Process materials to obtain the same (high grade) or lower (low grade) quality
	R9	Recover	Incineration of materials with energy recovery

pbl.nl

PBL Netherlands Environmental Assessment Agency: Potting J, Hekkert M, Worrell E and Hanemaaijer A, (2016). *Circular Economy: Measuring innovation in product chains.* PBL Netherlands Environmental Assessment Agency, The Hague. *Image used with permission.*

Value is retained through increased usage and longevity



IRP (2018). *Re-defining Value – The Manufacturing Revolution. Remanufacturing, Refurbishment, Repair and Direct Reuse in the Circular Economy.* Nabil Nasr, Jennifer Russell, Stefan Bringezu, Stefanie Hellweg, Brian Hilton, Cory Kreiss, and Nadia von Gries. A Report of the International Resource Panel. United Nations Environment Programme, Nairobi, Kenya. *Figure used with permission.*

ReSOLVE Framework

Exhibit 10 from “Growth within: A circular economy vision for a competitive Europe”, June 2015, McKinsey & Company, www.mckinsey.com.

THE RESOLVE FRAMEWORK

	Examples
REGENERATE	• Shift to renewable energy and materials • Reclaim, retain, and restore health of ecosystems • Return recovered biological resources to the biosphere
SHARE	• Share assets (e.g. cars, rooms, appliances) • Reuse/secondhand • Prolong life through maintenance, design for durability, upgradability, etc.
OPTIMISE	• Increase performance/efficiency of product • Remove waste in production and supply chain • Leverage big data, automation, remote sensing and steering
LOOP	• Remanufacture products or components • Recycle materials • Digest anaerobic • Extract biochemicals from organic waste
VIRTUALISE	• Dematerialise directly, e.g., books, CDs, DVDs, travel • Dematerialise indirectly, e.g., online shopping, autonomous vehicles
EXPLORE	• Replace old with advanced non-renewable materials • Apply new technologies (e.g. 3D printing) • Choose new product/service (e.g. multimodal transport)

We need to apply out of the box thinking…..

….but remember that the solution might need an out of the box ecosystem to be successful

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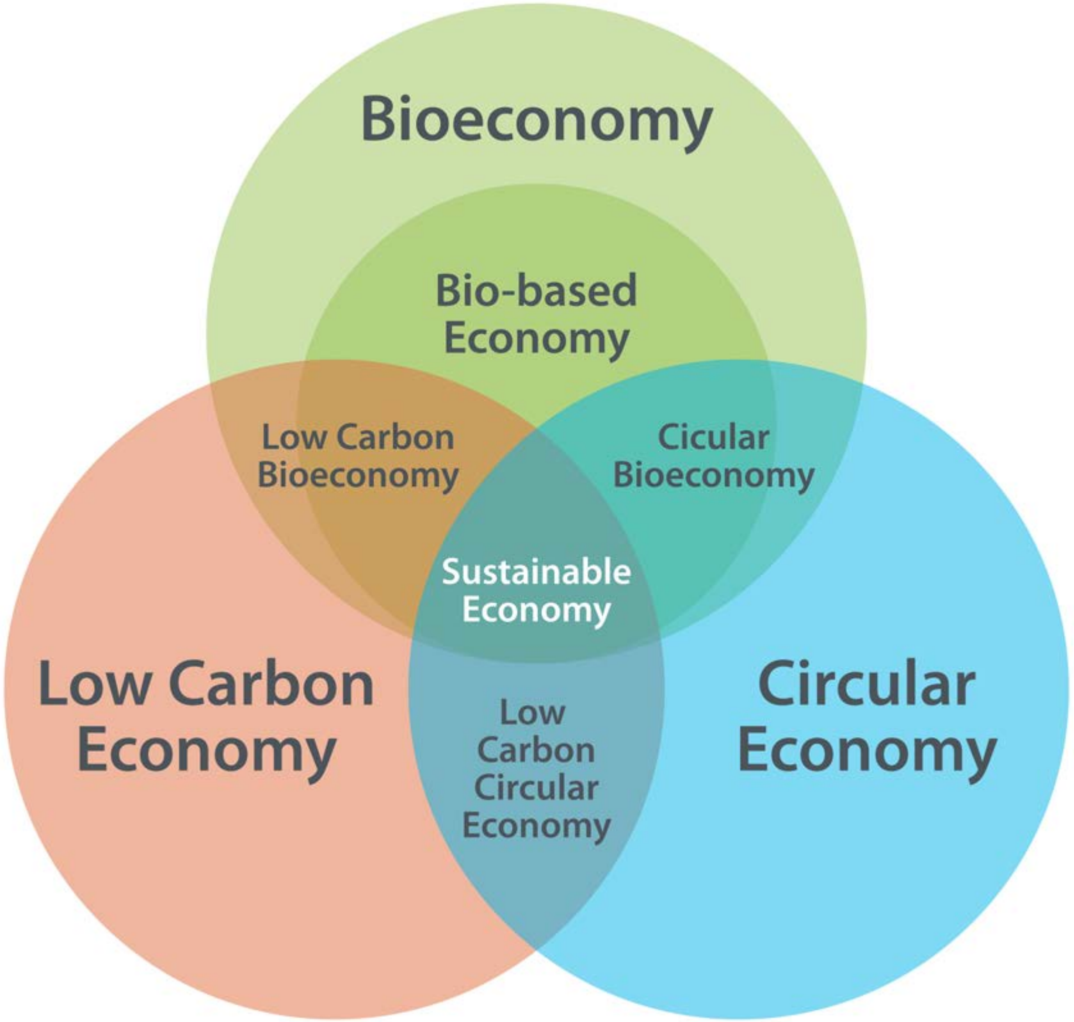
Why CE?

- What is the goal?
- Circularity for circularity?
- Is circularity a goal? Or a tool?



The Seven Pillars of the Circular Economy

- Materials are cycled at continuous high value
- All **energy** is based on renewable sources.
- **Biodiversity** is supported and enhanced through human activity.
- Human **society and culture are preserved**.
- The **health and wellbeing** of humans and other species are structurally supported
- Human activities maximize generation of societal value
- **Water resources** are extracted and cycled sustainably.

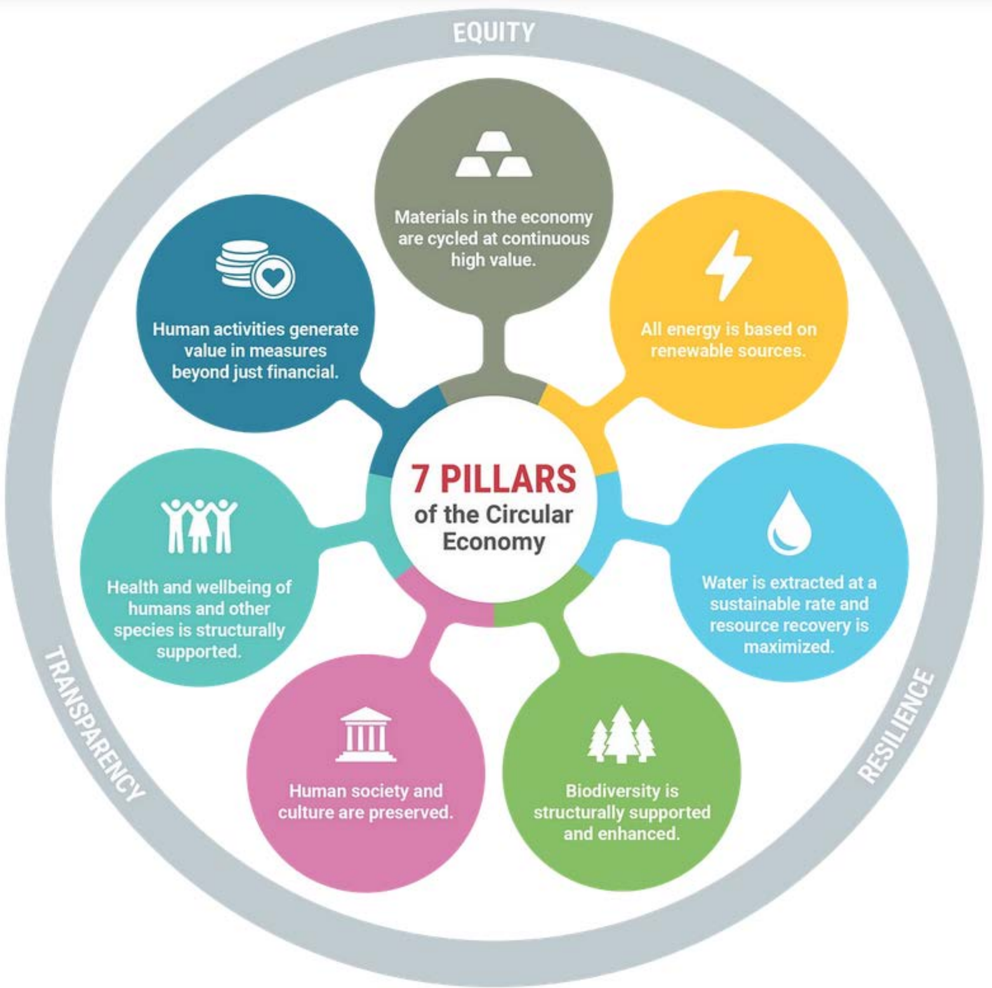


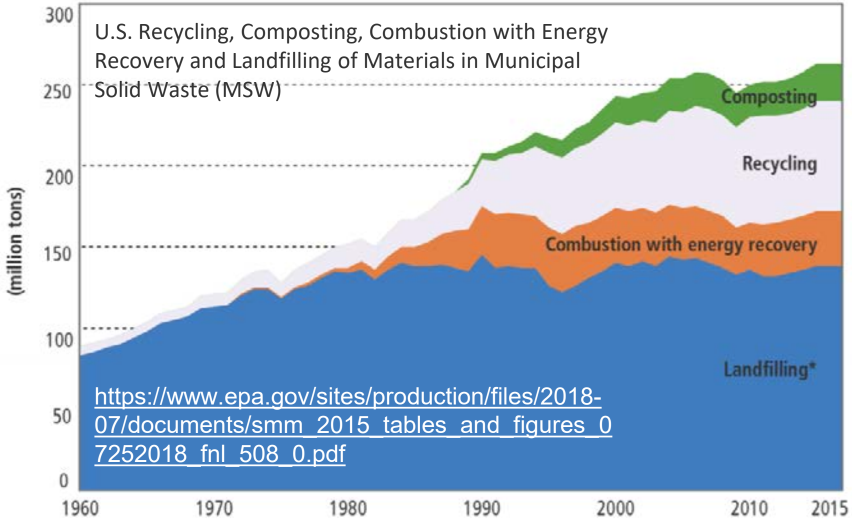
Image used with permission from Metabolic
https://www.metabolic.nl/news/the-seven-pillars-of-the-circular-economy/

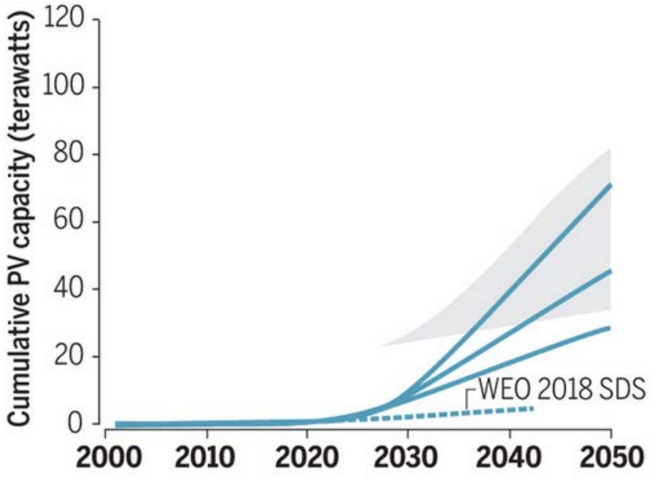
Why do we care?

- From EERE perspective, CE provides strategic opportunity to:
  - Support robust and secure supply chains
  - **Enhance domestic manufacturing** and industry
  - Maximize product and material value
  - Support the **growth of the material recovery industry**
  - Lead in the development and commercialization of end-of-life processing technologies
  - Minimize **life cycle impacts of US manufacturing products**

Why does/should society and communities care?

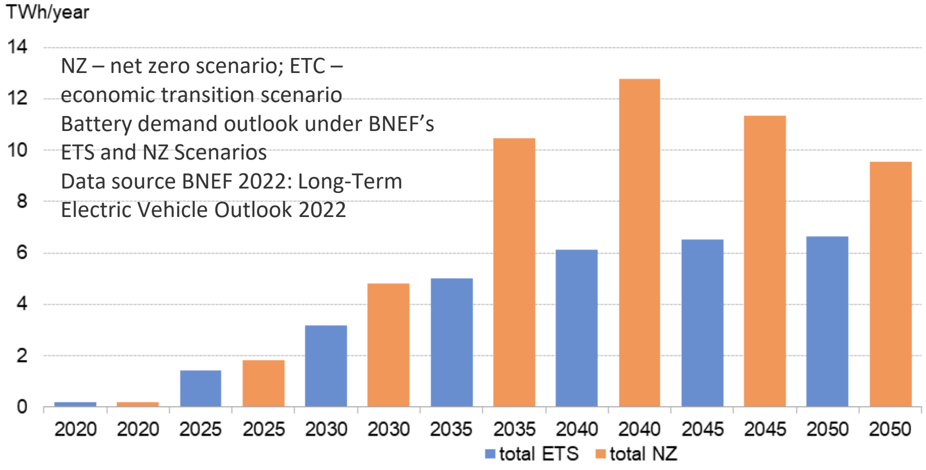
Sustainable development is defined globally as **meeting the needs of the present without compromising the well-being of future generations** (United Nations General Assembly 1987, 41). For the United States, sustainable development means a commitment "to create and maintain conditions under which **humans and nature can exist in productive harmony**, that permit fulfilling the social, economic and other requirements of present and future generations" (NEPA 1969).

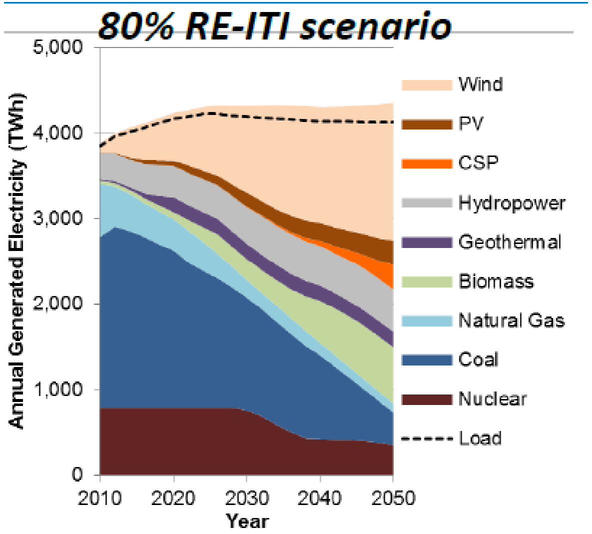




Scenarios for growth of PV - Total final consumption and world electricity, according to the 2018 World Energy Outlook (WEO) New Policies Scenario.

From Haegel, Nancy M., Harry Atwater Jr., Teresa Barnes, Christian Breyer, Anthony Burrell, Yet-Ming Chiang, Stefaan De Wolf, and Andreas W. Bett. 2019. "Terawatt-Scale Photovoltaics: Transform Global Energy." Science 364(6443) 836–838. https://doi.org/10.1126/science.aaw1845. Reprinted with permission from AAAS.





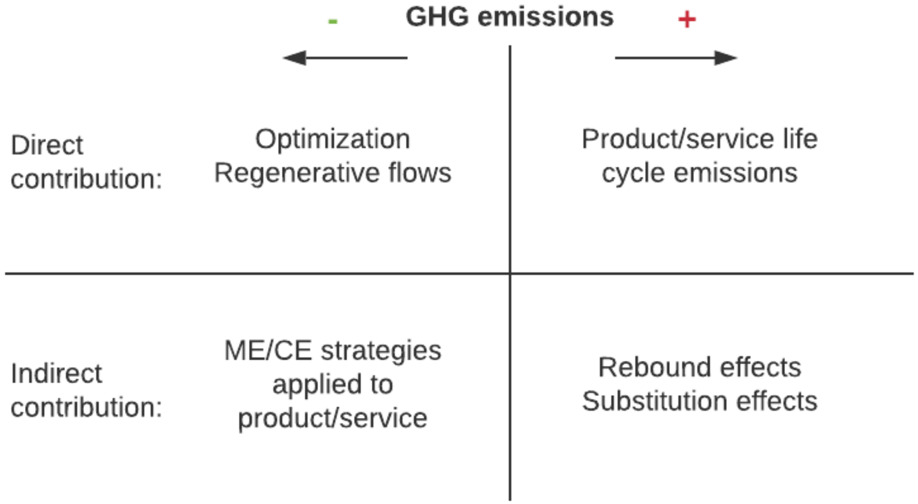
Renewable Electricity Futures (Presentation) NREL (National Renewable Energy Laboratory) NREL/PR-6A20-56118

CE & Decarbonization – *facts*

- Doubling global circularity from its current figure of 8.6% (i.e., only closing the circularity gap partially) could contribute up to 85% of the greenhouse gas (GHG) emission reductions needed to limit global warming below 2°C (Circle Economy 2021) → however, the gap is growing (9.1% circular in 2018 to 8.6% in 2020)!

- Examples of contribution of CE to decarbonization:
  - Extending a building's lifetime by 50 years could save 400 Mt of CO_2eq/year (Cai et al., 2012)
  - Light-weighting (e.g., using aluminum) ↓ mass by 26%, avoiding 8% of cars GHG emissions (Modaresi et al., 2014)
  - Energy sector (Cantzler et al., 2020): Repurposed electric vehicle batteries in houses ↓ GHG emission by 58%

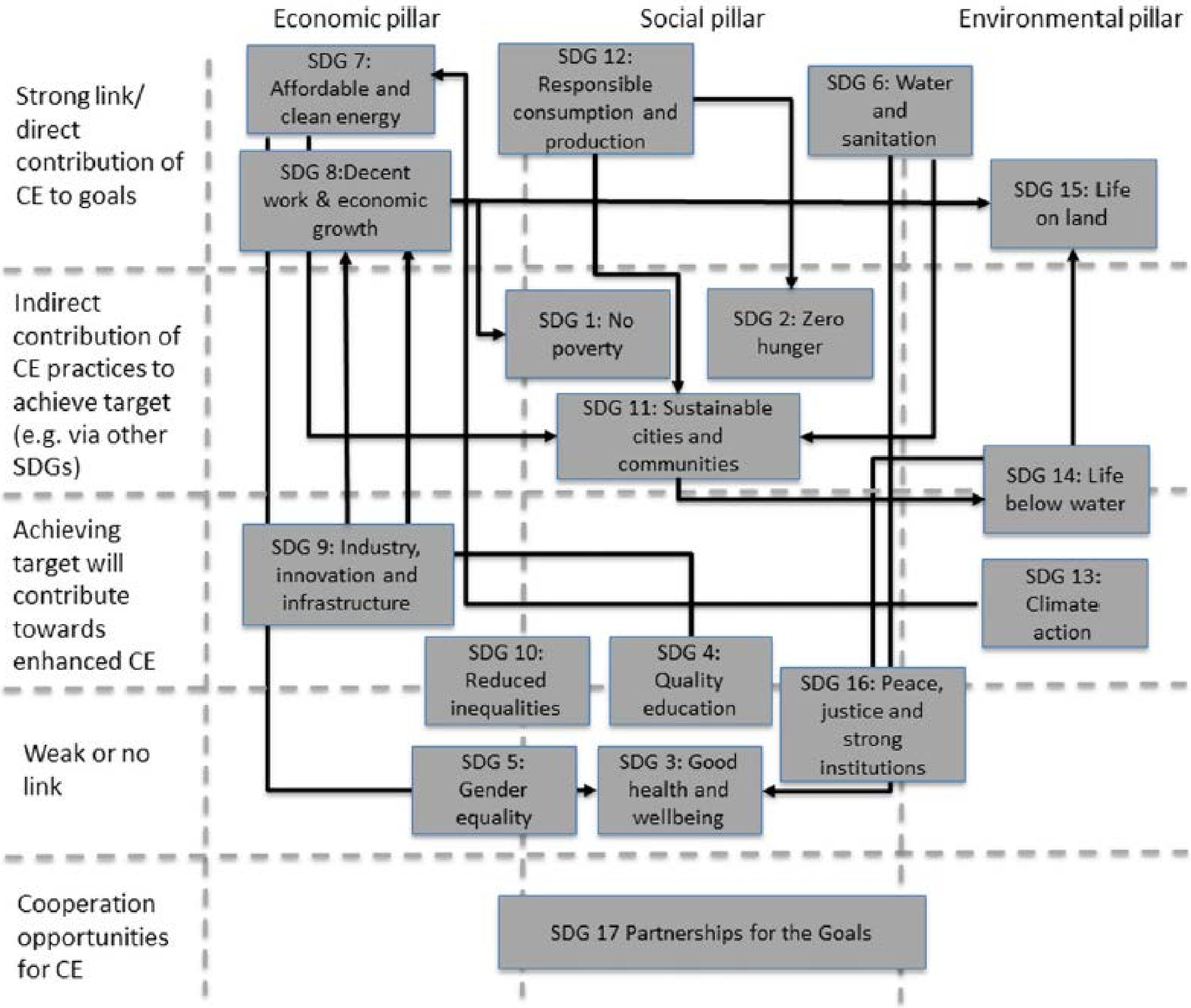
- CE can directly or indirectly contribute to decarbonization
- **What are the direct or indirect ways CE can contribute to EEJ?**



The two contribution levels of a product / service to decarbonization

CE connections to UN SDGs

-Schroeder, P., Anggraeni, K., & Weber, U. (2019). The Relevance of Circular Economy Practices to the Sustainable Development Goals. Journal of Industrial Ecology, 23(1), 77-95. doi:https://doi.org/10.1111/jiec.12732



CE & Decarbonization – *research needs*

- There are possible trade-off between material efficiency (ME) and operational energy for instance:
  - Use of timber structures ↓ buildings' material-related GHG emissions but ↑ GHG emissions during operation due to lower thermal performances
  - Prolonging lifetimes of material stocks versus improving their energy efficiency (Haas et al., 2020):
    - For instance, in the transportation sector fuel-efficiency increases by 1.8-3% per year
  - Vehicle electrification ↓ operation GHG emissions but ↑ material-related GHG emissions

→ Research is needed to investigate trade-offs

- **BUT:** Existing policy instrument such as landfill bans or dedicated parking space for car sharing can already be leveraged to increase circularity and contribute to decarbonization!

		Material-related GHG emissions		
		Decreasing	**Neutral**	**Increasing**
Operation-related GHG emissions	**Increasing**	**-Buildings:** lifetime extension, wood structures, cement recycling **-Vehicles:** lifetime extension	**-Buildings:** higher indoor temperature	**-Buildings:** larger **-Vehicles:** larger
	Neutral	**-Buildings:** steel recycling **-Vehicles:** more intensive use (e.g., sharing), recycling		
	Decreasing	**-Buildings:** smaller, more intensive use **-Vehicles:** smaller light-weighting	**-Buildings:** better indoor temperature management **-Vehicles:** driving style, improved engine control	**-Buildings:** extra insulation, stock renewal, heat storage design **-Vehicles:** electrification

Trade-offs of ME strategies in buildings and vehicles (adapted from Hertwich et al. (2019))

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What are the research needs to better understand the connections between CE and EEJ?

Guiding CE Research Questions

Circular

- How circular are current clea
- How might clean energy tech
- How might the costs of clean n energy supply chains become more circular?
- How might policy and regulat

Sustainable

- **What are the externalities** as ow sustainable are current decarbonization pathways?
- How might those externalitie
- **Where are these impacts dis** change as supply chains become more circular?

Resilient - Robust to Supply Chain

- How can a circular economy **r** energy economy?
- Which types of circular economy pathways present the greatest **opportunities for reducing our dependence on international supply chains f**or clean energy technologies (e.g., for critical materials such as Dysprosium)?
- How might circularity transitions influence the type and quantity of materials that are required for clean energy technologies, including our dependence on non-domestic sources of these materials?

How can we adjust or revise these questions to more explicitly include EEJ?

And

What are other questions that are more central to EEJ and CE connections?

And

What is the relevance?

Sample CE Research Questions and Relevance

CE Research Question	Relevance
How does transitioning toward a CE directly impact the rate of virgin material consumption in the system?	quantify the decrease (or increase) of the use of virgin materials, especially those that are constrained in supply or are vulnerable to supply risks (e.g., critical materials).
How does transitioning toward a CE improve the efficiency of processes and reduce waste production?	be able to quantify the impacts of CE strategies on process efficiency improvements and waste minimization.
How does implementing CE strategies affect social factors (i.e., equity, jobs, healthy living and working conditions)? Does it disproportionately negatively affect certain groups and communities?	consider the societal impacts on those who directly benefit from or are harmed by the implementation of CE strategies in a technology sector. An understanding of the positive and negative impacts on society provides a starting point for devising solutions that provide equitable benefits.
How does implementing CE strategies impact the sustainability performance of the system? Does it shift negative sustainability impacts outside the system of study?	CE is intended to be the means to improve the sustainability of the system, and not be the end goal. An understanding of the sustainability performance and tradeoffs of implementing CE strategies helps improve decision-making.
How does implementing CE strategies affect key players in the value chain of the system? What are the tradeoffs from the perspective of different stakeholders?	Implementing a CE strategy requires systemic change from actors along the value chain of a technology.

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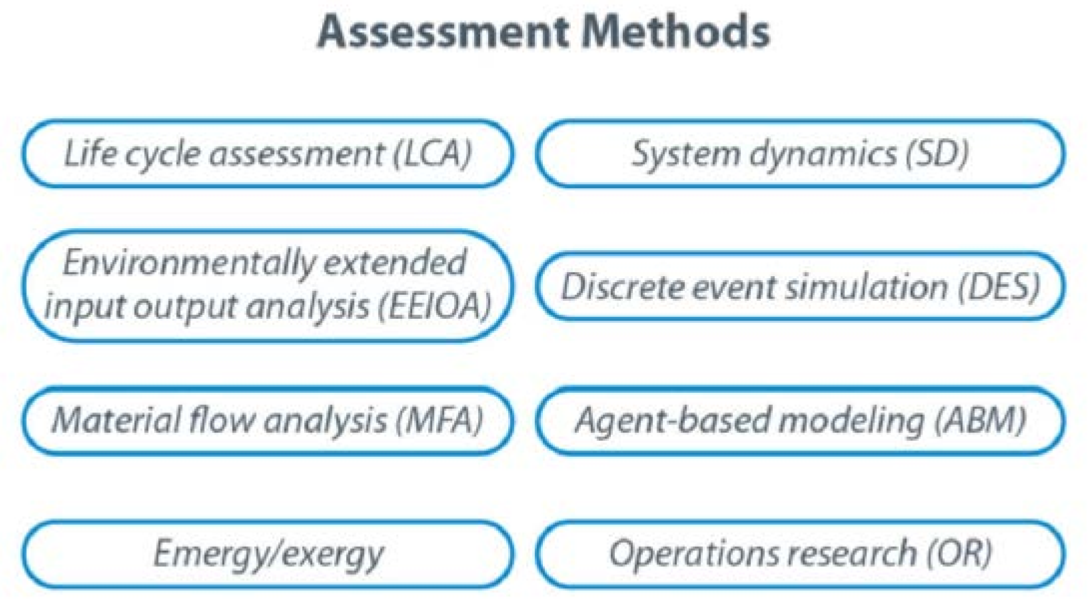
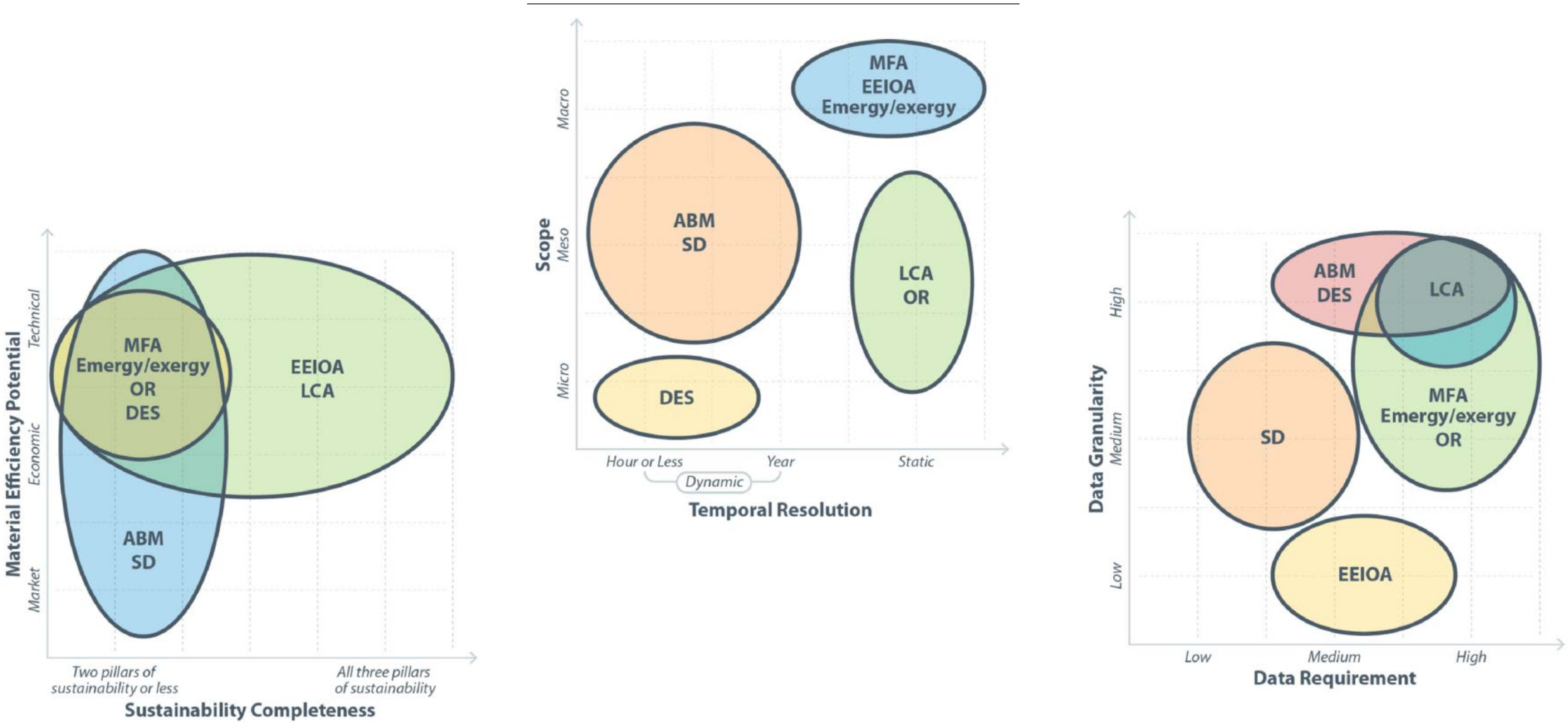
How do we evaluate CE?

This depends on the research question



Walzberg et al, *Frontiers in Sustainability* 1:620047 (2020). https://doi.org/10.3389/frsus.2020.620047

How do we evaluate CE?



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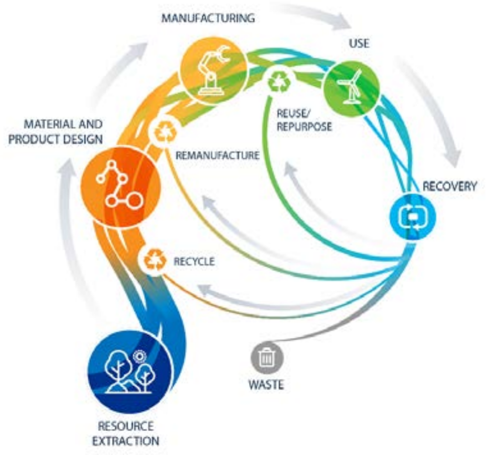
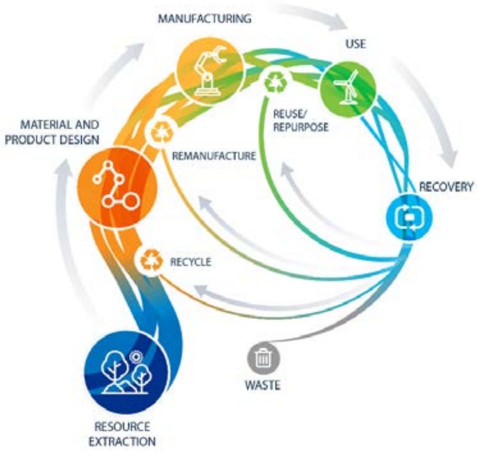
EEJ tools and metrics



- Can we utilize existing methods or do we need to revisit the question of whether we need a new methodology to understand EEJ and CE?
- LCA can start us down the line and has some capability to answer some EEJ questions
  - PROS: can evaluate life cycle impacts around human toxicity, air quality, water quality and resource use.
  - CONS:
    - Needs better data to provide more specificity and understanding of the uncertainties
    - Needs more geospatial resolution to understand where emissions are occurring and how they are specifically impacting those communities
    - Needs the ability to evaluate scenarios across multiple lifetimes (dynamic)
- Agent-based modeling (ABM) can help us understand how communities and different actors will react to a new technology, and what are the most important drivers. Will a technology be accepted or adopted and what can facilitate adoption and to what extent.
  - Can be connected to LCA to provide more realistic scenario analysis

EEJ tools and metrics

- What is not covered?



Food for thought

- Are the fruits of your research providing equitable benefits across society?
  - If not – Does it need to? And do we make that happen?
  - Work on EV’s has been ongoing for decades, and the costs have dropped significantly, but EVs are not accessible to all levels of society
  - In order to achieve decarbonization goals, a large portion of transportation needs to be electrified by 2050. how do we achieve this if most of the population cannot afford to purchase an EV or have access to clean energy transportation services?

Questions?

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