

# Closing the Loop: Exploring Opportunities for Circular Economy Exchanges in Maine



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# AGENDA

## THE PROJECT

- Policy
- Planning
- Partners

## MATERIALS

- Per capita
- History
- Trade

## CIRCULARITY

- Economics
- Environment
- Community

## CASES

- Industrial Symbiosis
- Global cases
- Maine cases



# Maine Won't Wait 2024

Strategy F part 9:

“Maine should also investigate opportunities for industrial and regional materials exchanges”



# “Opportunities for Industrial Materials Exchange in Maine”

## 1. Workshops

Engage stakeholders to understand opportunities and barriers, as well as to build networks

## 3. Mapping

Map materials flows to identify opportunities for materials exchange

## 2. Surveys

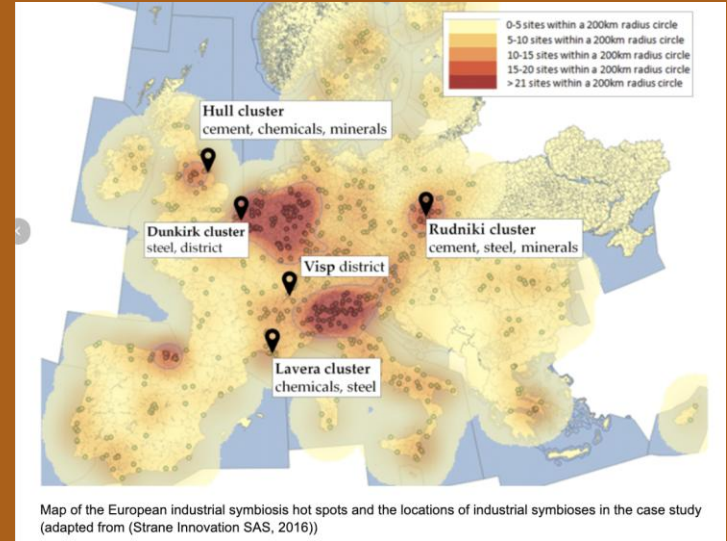
Survey partners about high volume wastes, inputs, opinions

## 4. Collaboration

Collaborative proposals for the next steps



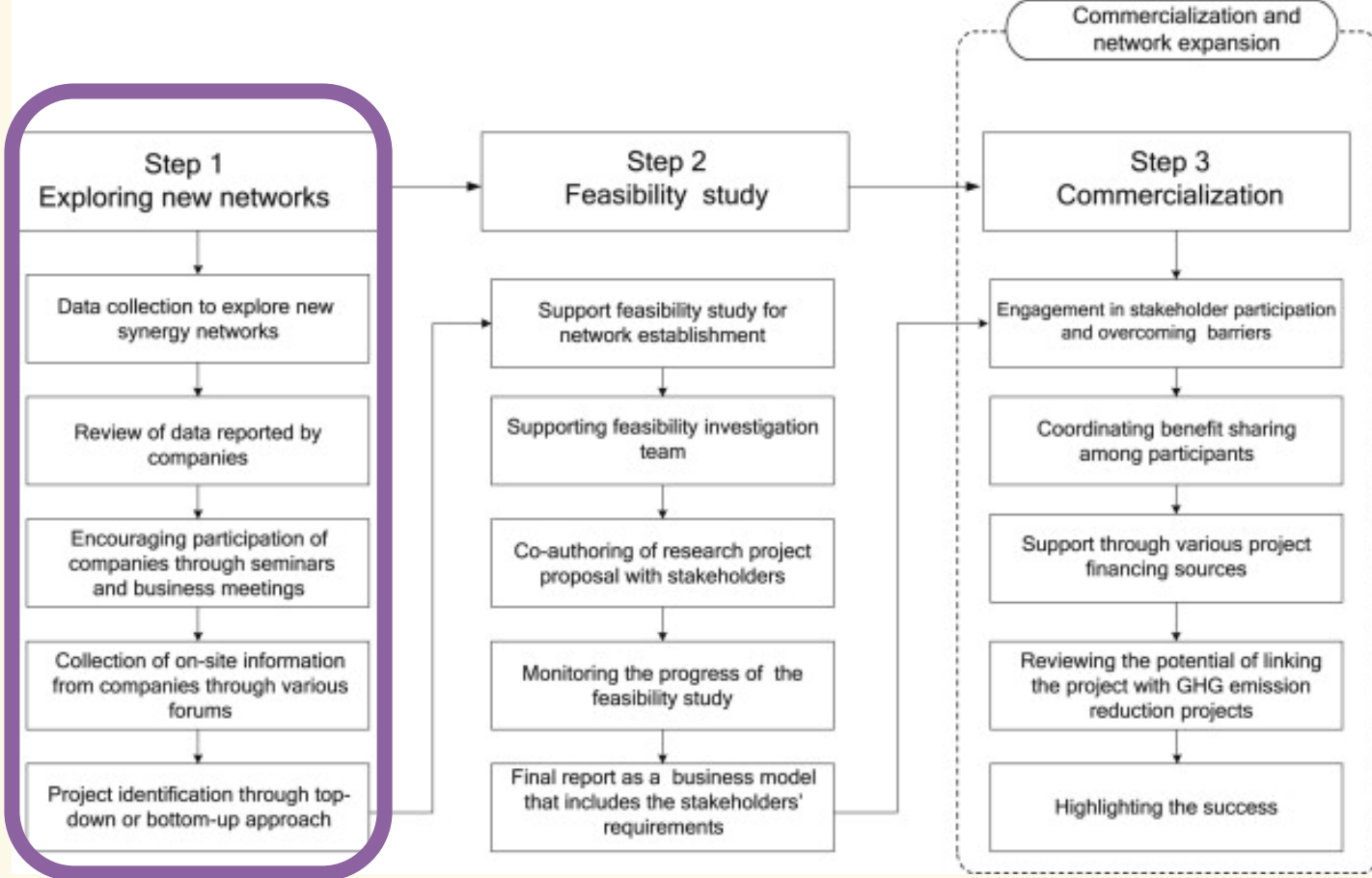
Senator George J. Mitchell  
Center for Sustainability Solutions



Map of the European industrial symbiosis hot spots and the locations of industrial symbioses in the case study (adapted from (Strane Innovation SAS, 2016))

# Timeline

Activity	Fall 2025	Spring 2026	Summer 2026	Fall 2026	Spring 2027	Summer 2027
Workshops	Light Purple			Light Purple		
Surveys	Dark Purple	Dark Purple				
Mapping		Yellow	Yellow			
Collaboration					Dark Purple	Dark Purple



## Steps toward establishing eco-industrial exchanges

Example: Ulsan Eco-Industrial Park in Korea, Behera et al (2012)

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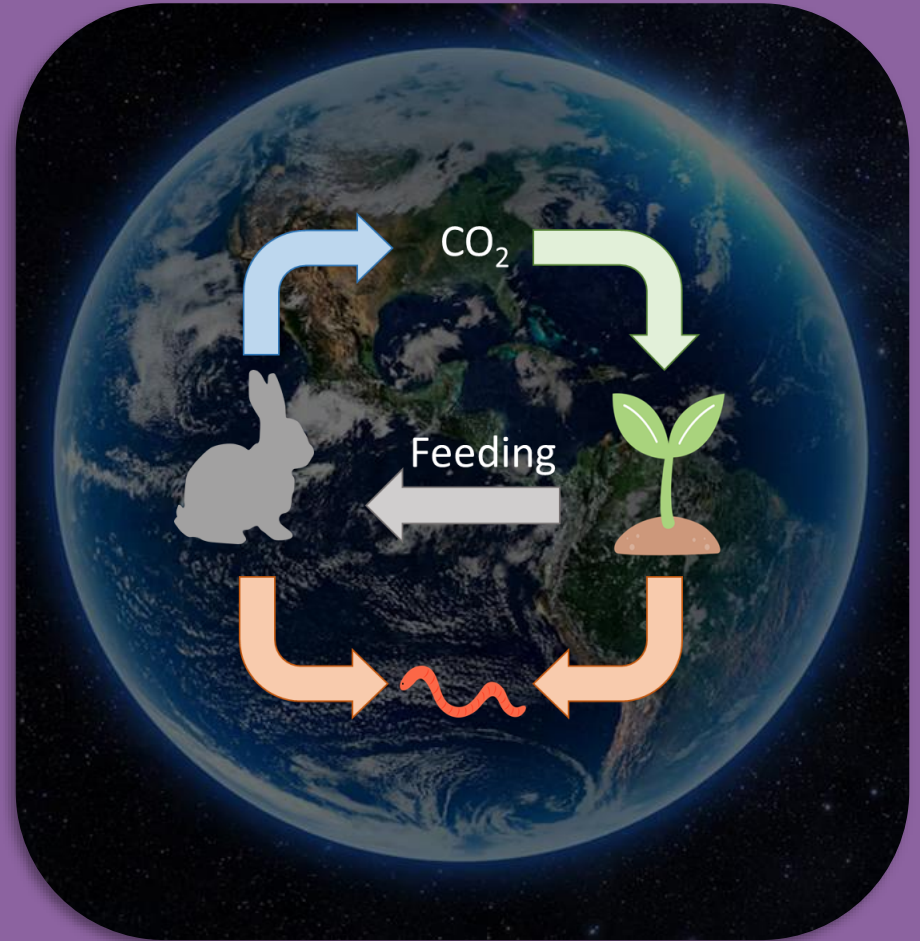
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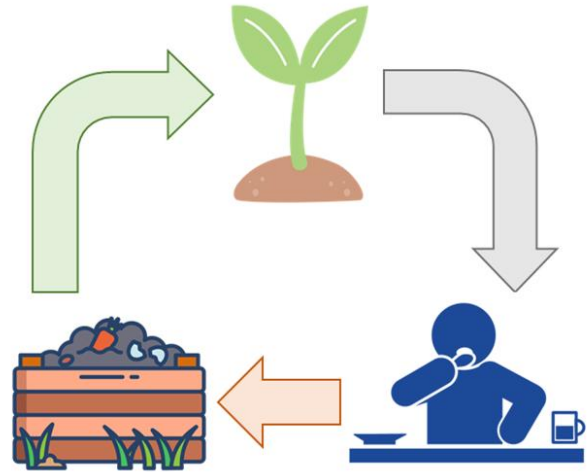
- Industrial Symbiosis
- Cases



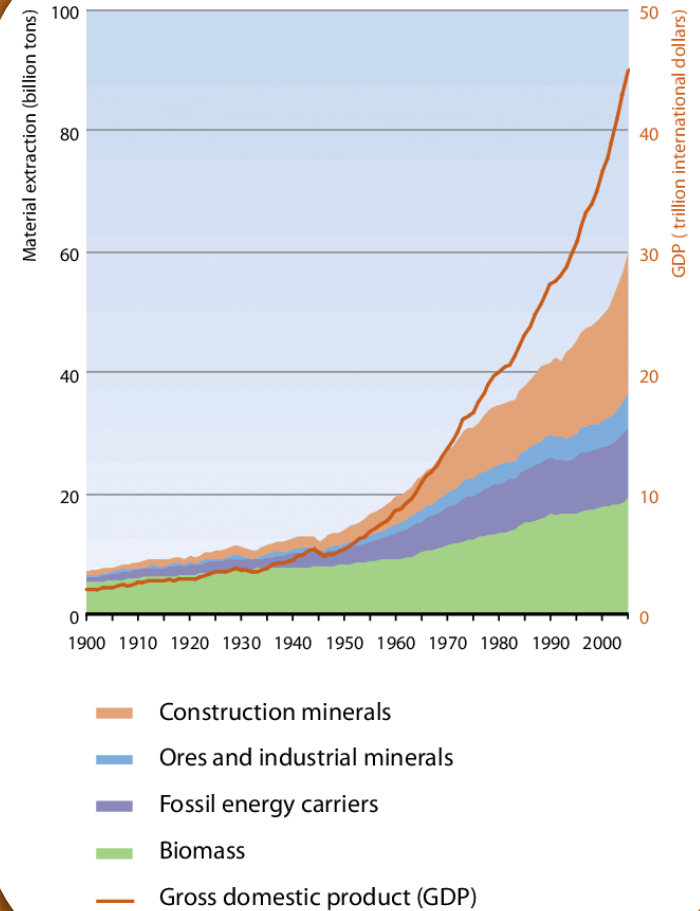
# IN NATURE STUFF CYCLES



# OUR STUFF TOO



# materials use





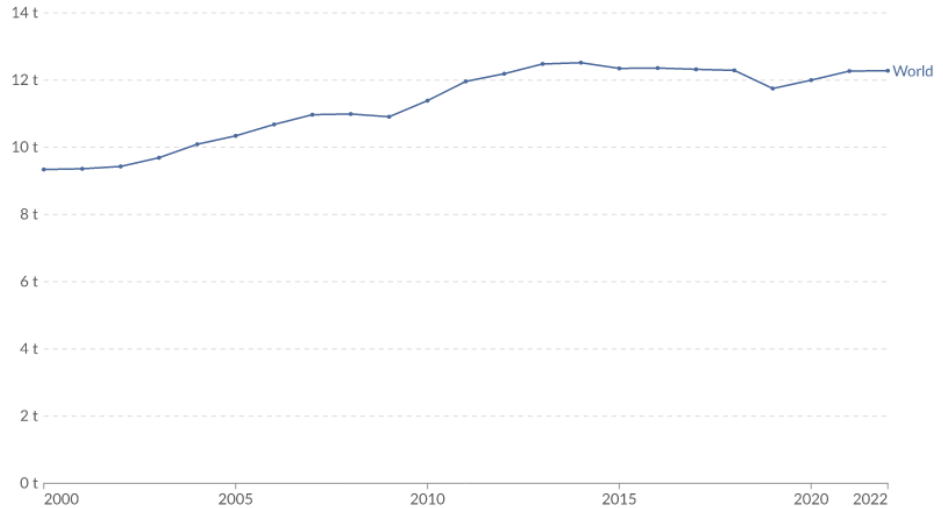
people and their stuff have changed

# materials use per capita

## Material footprint per capita, 2000 to 2022

Our World  
in Data

Material footprint is the quantity of material needed to meet a country's material demand. It is material production, adjusted for trade. The total material footprint is the sum of the material footprint for biomass, fossil fuels, metal ores, and non-metal ores, given in tonnes per year.



Data source: United Nations Environment Programme

OurWorldinData.org/biodiversity | CC BY

# linear material system

Involves energy, water and labor inputs, and pollution output at every stage



**RESOURCE  
EXTRACTION**



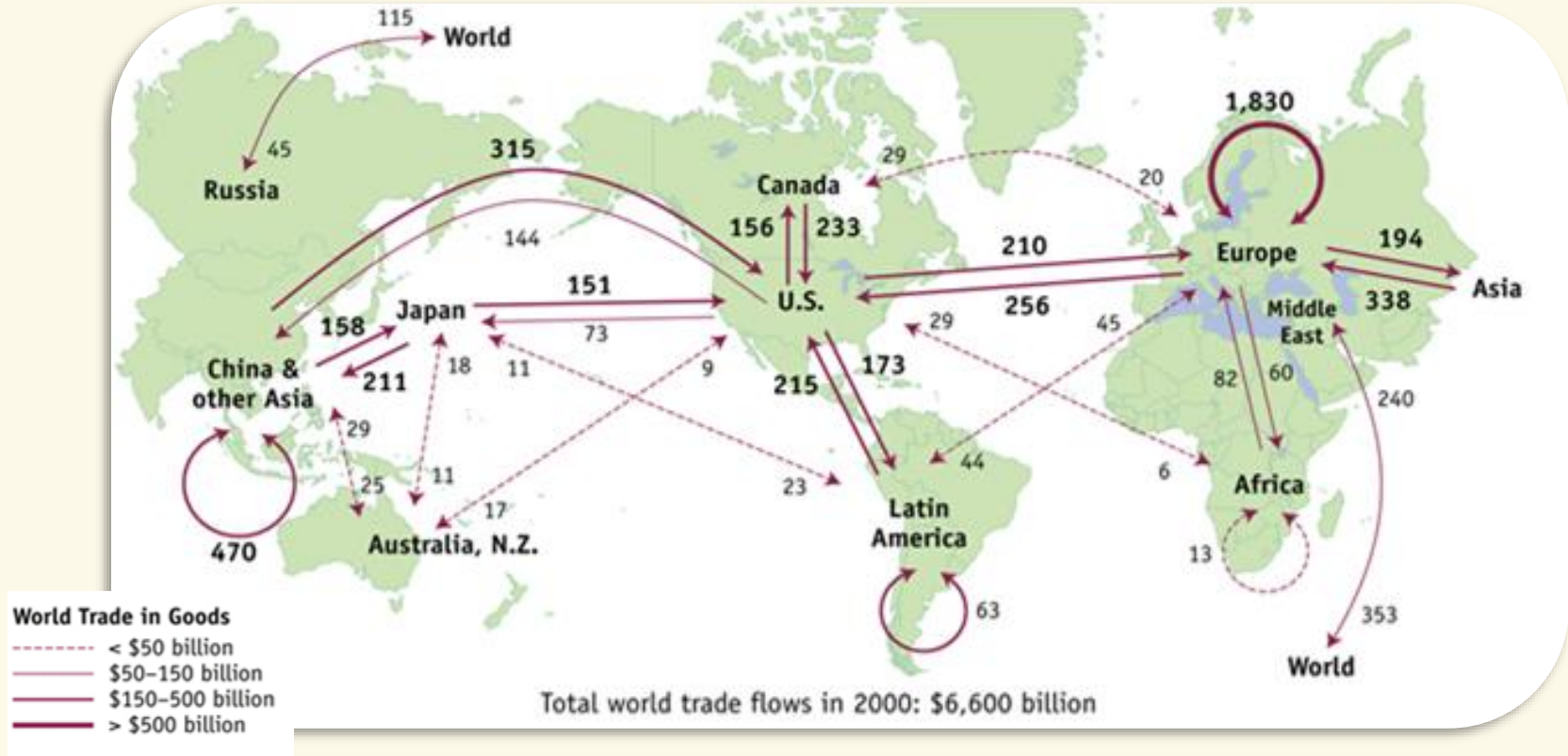
**MANUFACTURING**



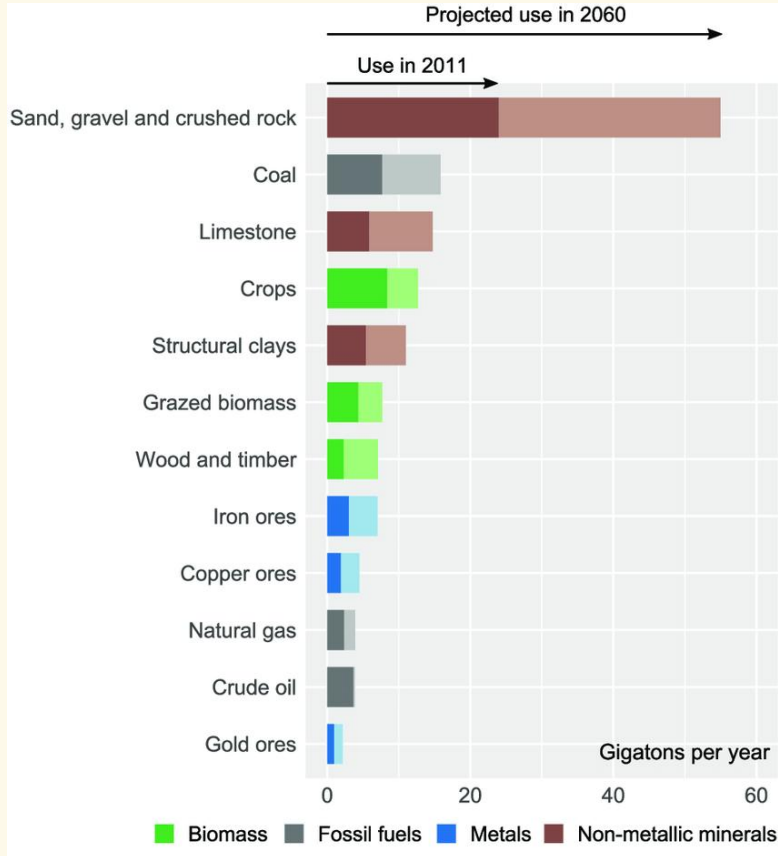
**TRANSPORTATION**



**DISPOSAL**

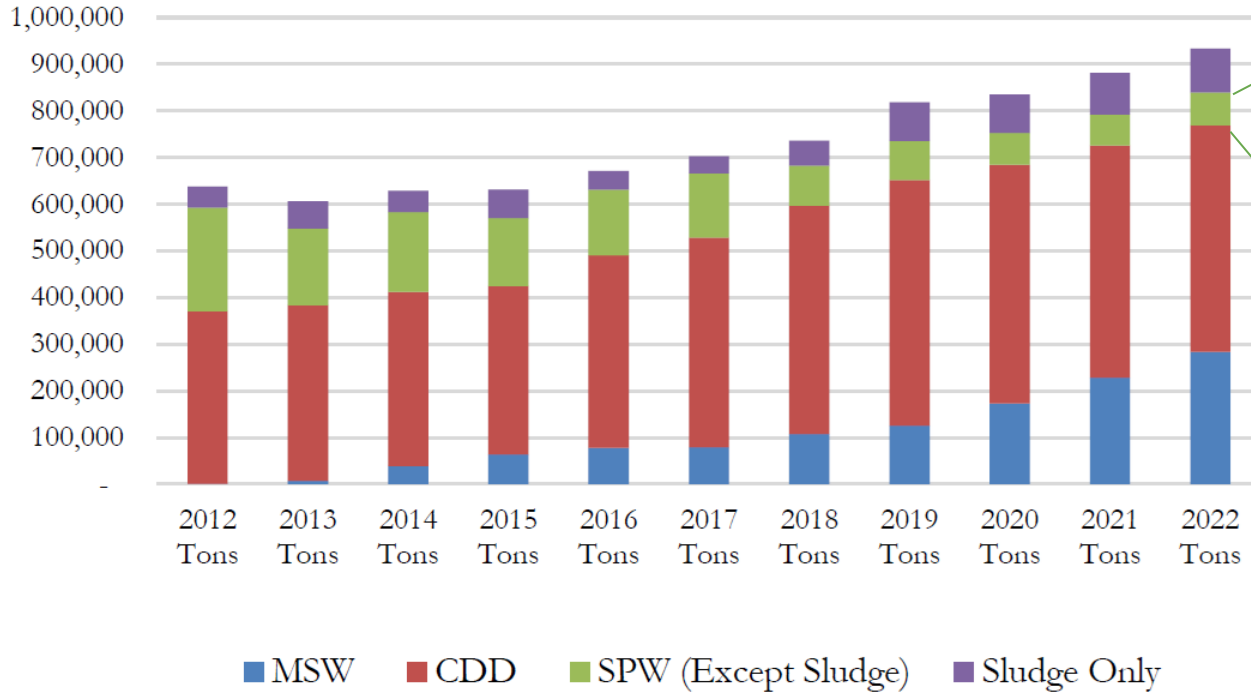


Products are not made where they are **used**  
 Discarded materials are not where they are **needed**



The really high volume materials are used in construction and energy

## Juniper Ridge - Wastes Accepted by Amount, 2012-2022



**Some interesting industrial SPW:**

1,917t polyethylene and cellulose trimmings

1,033t non-hazardous chemicals

751t pulp mill waste

525t Industrial Miscellaneous

# Juniper Ridge receives Special Wastes (SPW)

Thinking about your community, what are some high-volume materials currently going to waste?

transpiration  
leader bold  
creative  
fast focus  
inspiration



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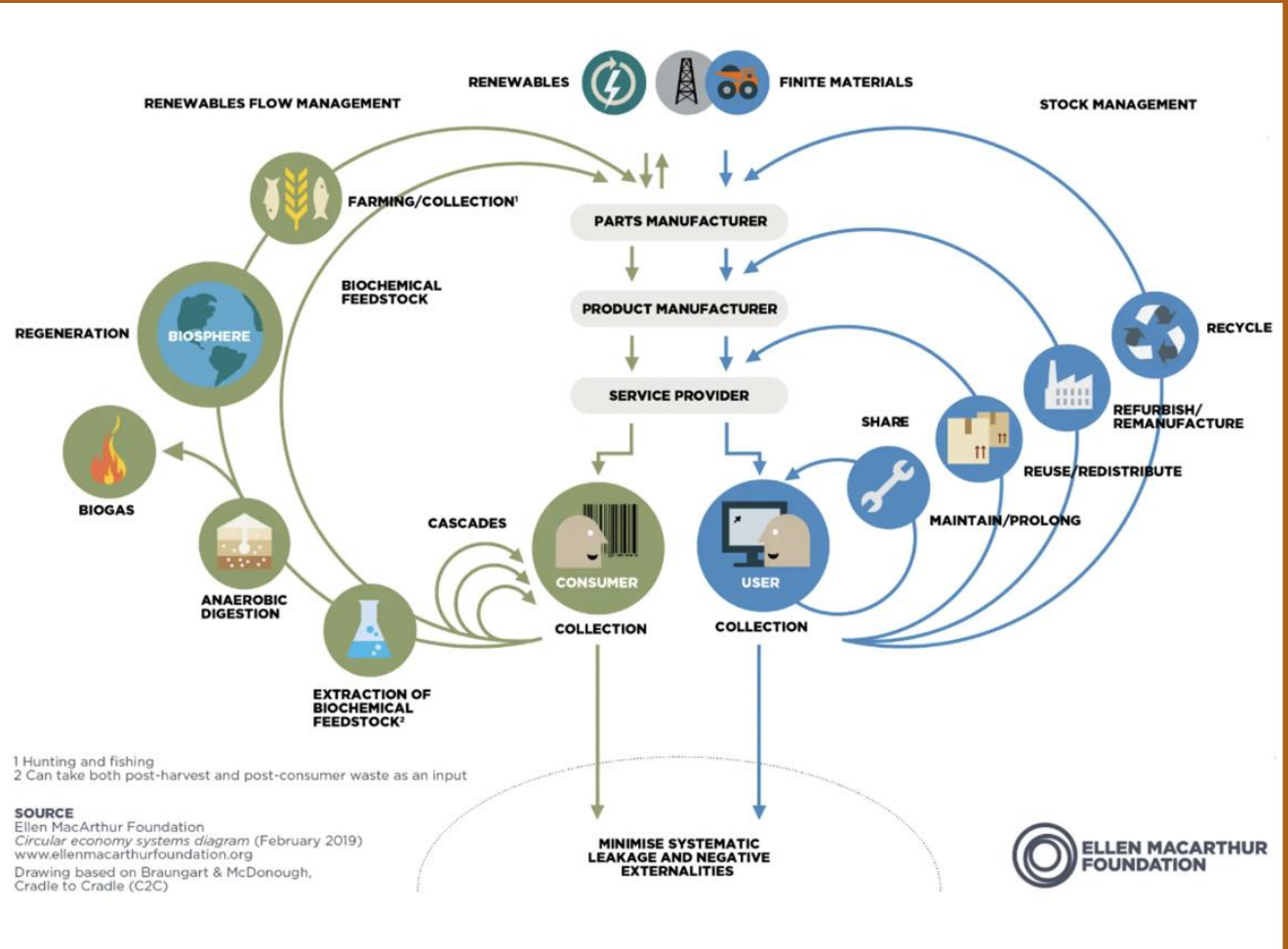


# Circular Economy

Eliminate waste & pollution

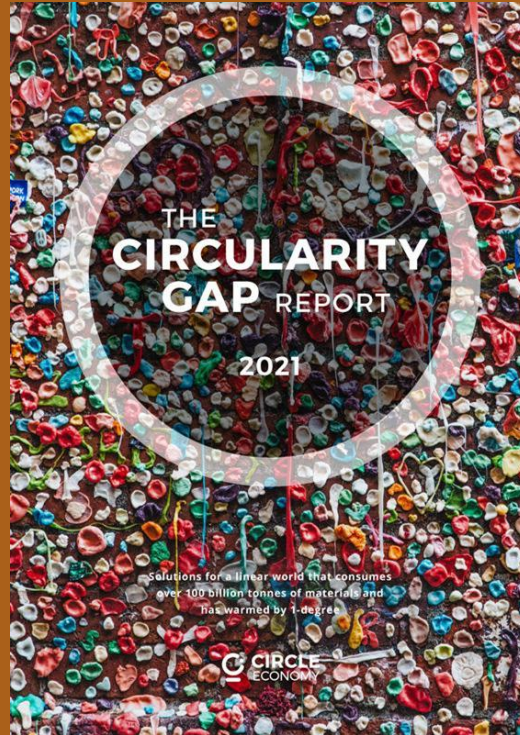
Circulate materials

Regenerate nature

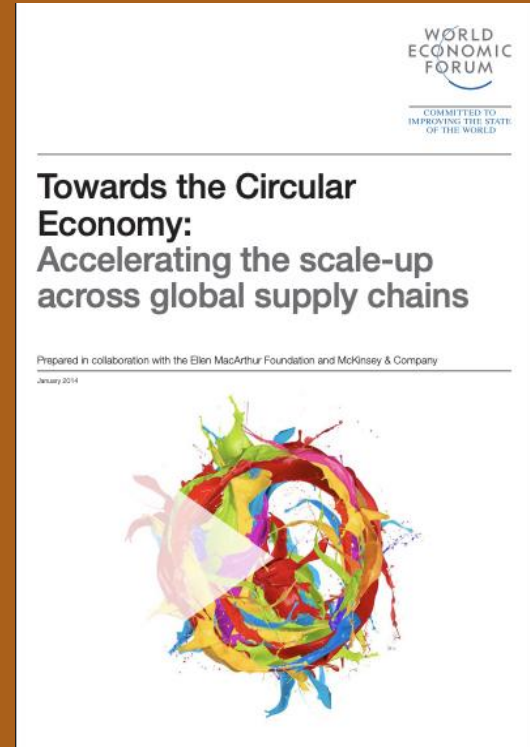




Projections of 2-8  
Million New Jobs



39% Reduction in  
GHG



\$1 Trillion annually  
in materials and  
waste savings

# The Potential of Circularity

Material Savings (WBCSD 2024)

Environmental Benefits (EMF2024)

Economic Savings (EMF 2024)

Regional Resilience (Howard et. al 2022)

Economic Development (WRI 2021)

Social Capital (Berry 2019)

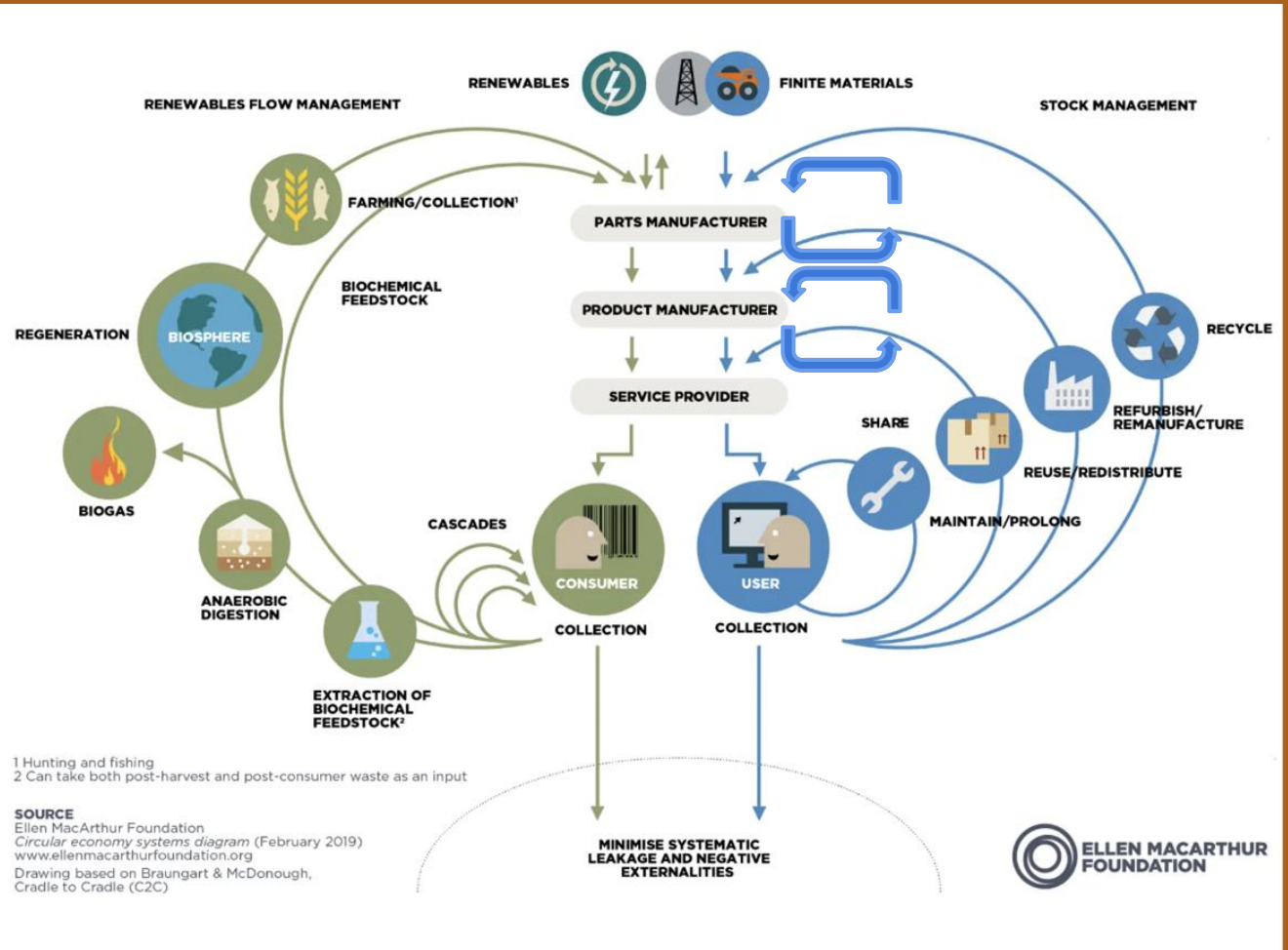


# Circular Economy

Eliminate waste & pollution

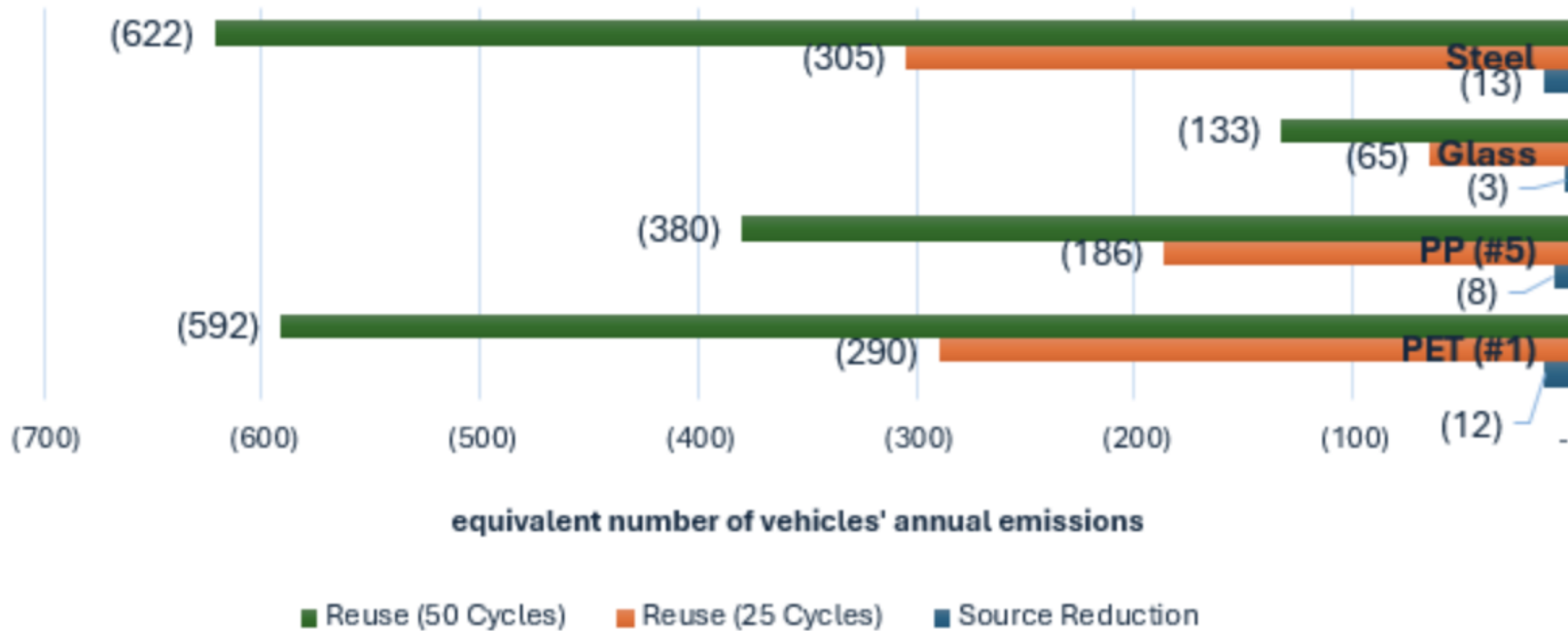
Circulate materials

Regenerate nature



## Reuse vs. Recycling 50 Tons of Packaging

emissions impacts of material pathways



In your community, which types of waste materials would make the most positive impact, if circularized?

Default ▾



**B**

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Industrial wastes

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Building materials

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Construction and Demolition Debris

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MSW Recyclables

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Healthcare waste

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Low Impact

High Impact



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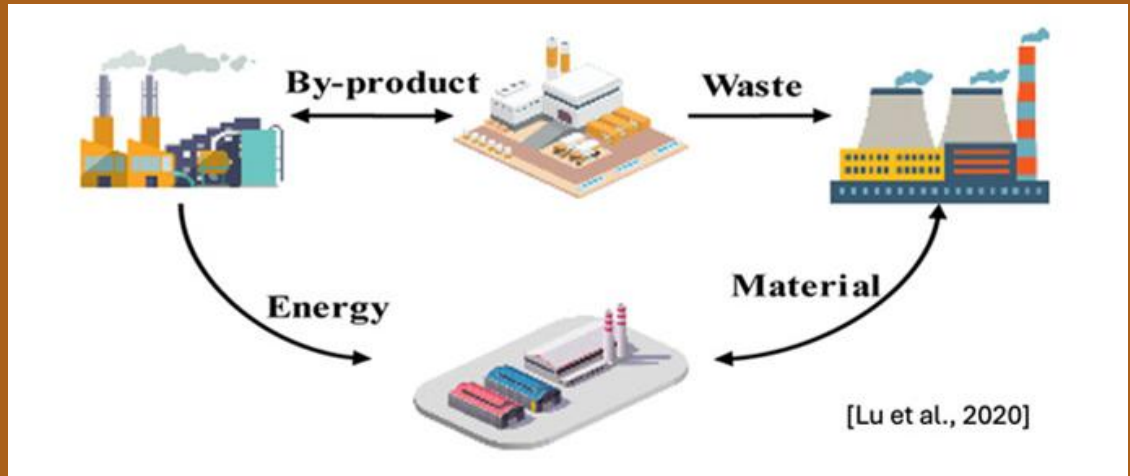
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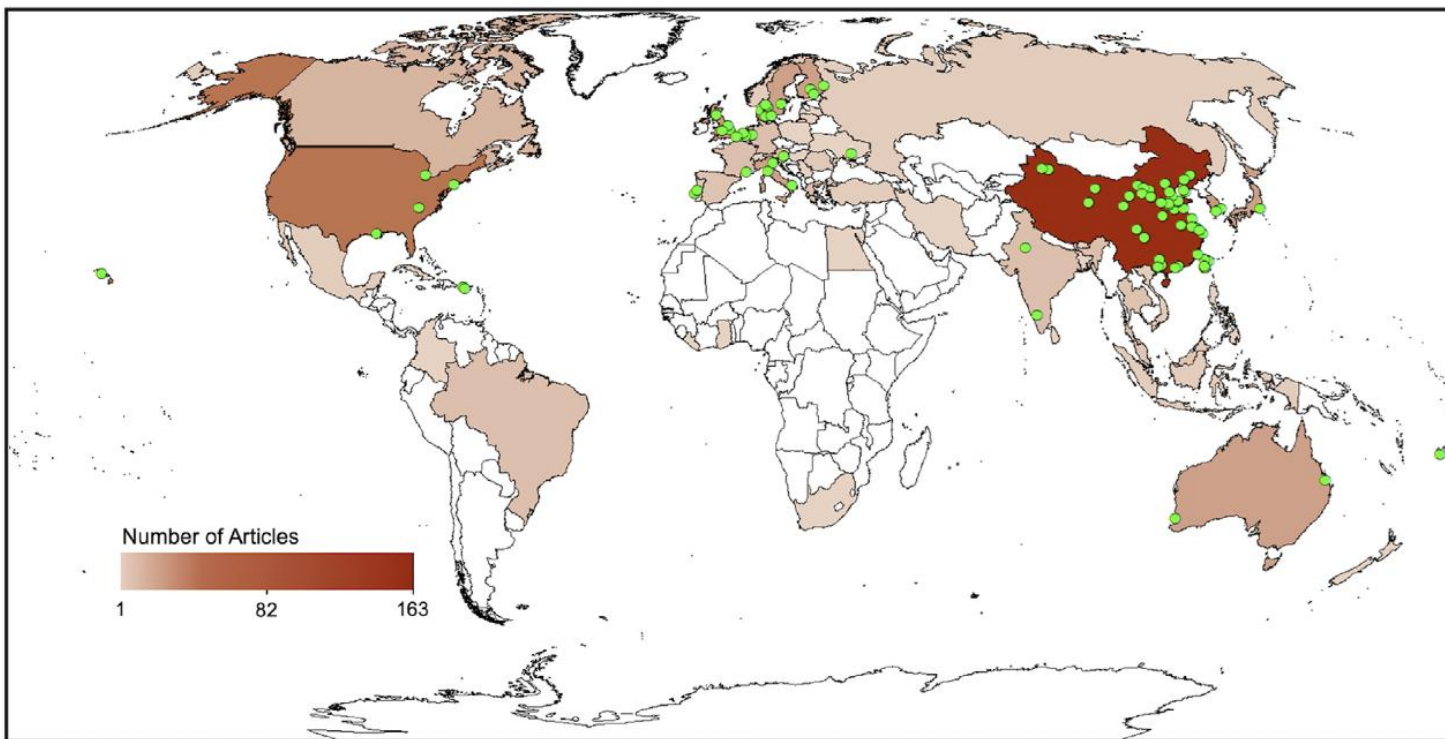
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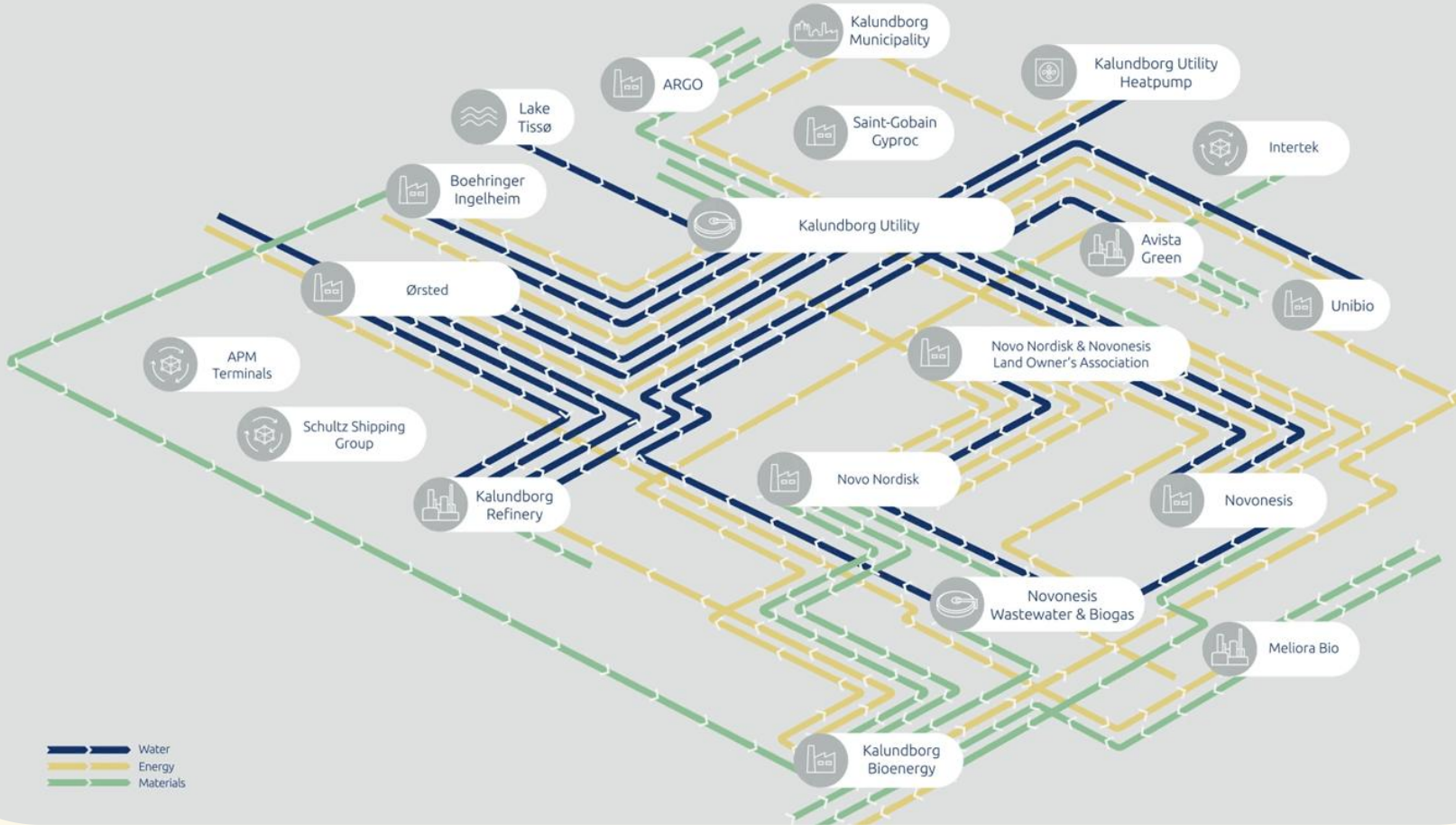
# Industrial Symbiosis:

inspired by mutualistic symbiosis in biological ecosystems





**FIGURE 4** Countries and industrial clusters featured in peer-reviewed journal articles on industrial symbiosis published from 1995 through 2018, acquired through keyword searches in Web of Science and Scopus. Shades of red represent the number of articles featuring each country. Green points denote industrial clusters where detailed information on individual, implemented, interfirm exchanges of energy and material by-products have been reported in the articles. Underlying numbers used to create this figure can be found in Supporting Information S2



 Water  
 Energy  
 Materials

# Kalundborg

[symbiosis.dk/en](http://symbiosis.dk/en)

## Energy

- 1 Steam
- 2 Electricity to the grid
- 3 Steam condensate
- 4 District heating
- 5 Biomethane
- 29 Power generation
- 33 Support fuels

## Water

- 6 Wastewater
- 7 Treated wastewater
- 8 Surface water
- 9 Used cooling water
- 10 Sewage water
- 11 Treated surface water
- 12 Flue gas condensate
- 30 Hot water

## Materials

- 13 Waste
- 14 Sulphur
- 15 Yeast cream
- 16 Sand
- 17 Sludge
- 18 NovoGro
- 19 Ethanol waste
- 20 Biomass
- 21 Fertilizer
- 22 Industrial recycling
- 23 Direct recycling
- 24 Sample residues
- 25 Straw
- 26 Lignin
- 27 Residues from other industries
- 28 Organic material
- 31 Used lubricating oil
- 32 Bottom fraction
- 34 Discarded powder products

# Kalundborg

[symbiosis.dk/en](http://symbiosis.dk/en)

## Results to Date

The Eco-Industrial Park saves Kalundborg €24 million in bottom-line savings annually. But the savings aren't just financial—this process saves **635,000 tons of CO2**, **3.6 million m3 of water**, **100 GWh of energy**, and **87,000 tons of solid materials**.

**635K**

tons in savings of CO2.

**3.6M**

m3 savings in water.

**100**

GWh in energy savings.

**87K**

tons of savings in solid waste.

The Kalundborg Eco-Industrial Park demonstrates how resource sharing among industrial actors in the same locality can be beneficial both ecologically and financially. For today's organizations, applying circular models can yield enormous benefits in several business-critical areas.

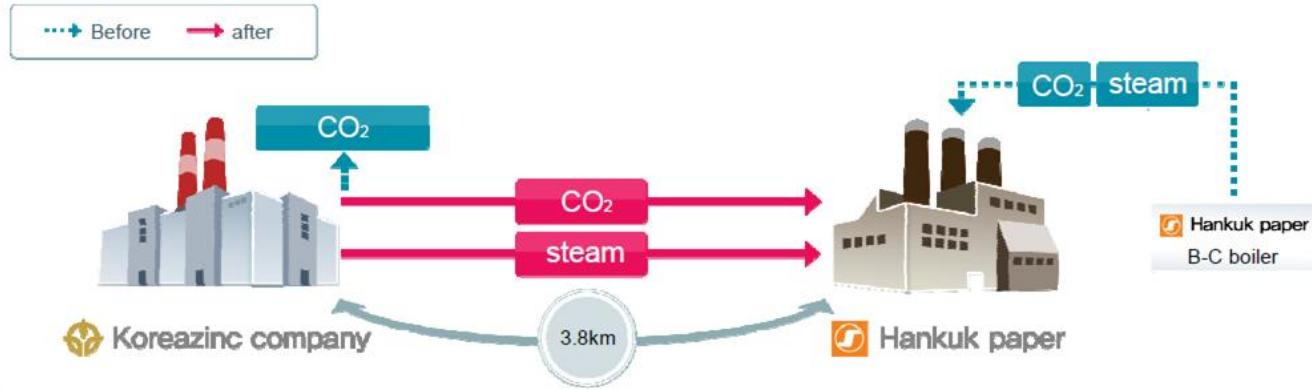
## Kalundborg annual savings



# Ulsan, South Korea

World Bank (2018)

## CO<sub>2</sub> and steam network between Paper mill and Zinc smelter



### ✓ Input(Initial Investment)

- Facility investment : steam and CO<sub>2</sub> pipe (total 3,872m) the cost of equipment : \$22.0 mil.

### ✓ Output(Income : Business scale : steam 50~80 ton/hr, CO<sub>2</sub> 50 ton/hr supply)

- Reduction of GHG emission : CO<sub>2</sub> 63,643 ton/yr (about \$ 0.7 mil./yr)
- Cost Cut from raw material & waste reduction : \$6.6 mil./yr

# Ulsan, South Korea

Park (2013)

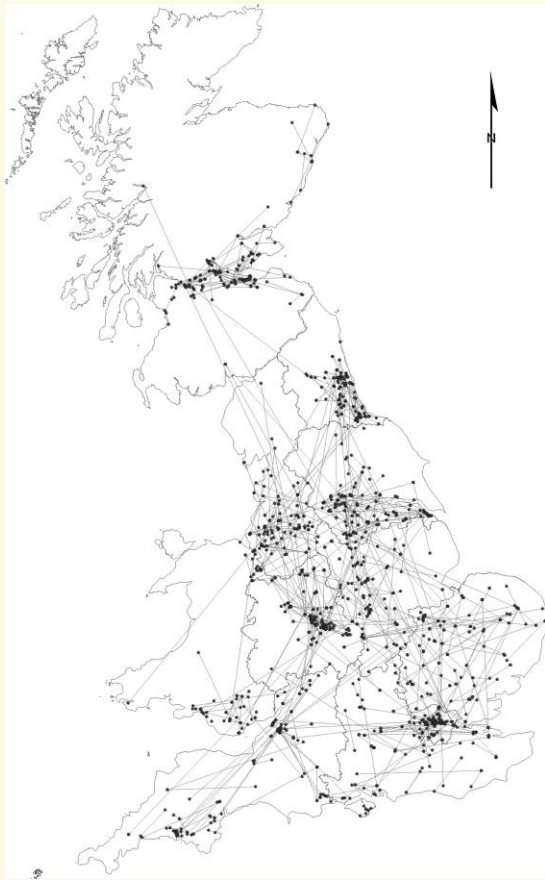


✓ Economical Result  
: \$ 2 mil./yr profit because of 2,703 toe/yr Energy substitution.

✓ Preparing for the Anti-Marine dumping Law effective from 2013.

## Ulsan, South Korea

Park (2013)



Voluntary, government-supported private sector initiative started in 2005

- 13,000 companies
- 20 miles average distance
- Trust & cooperation required

In 5 years, diverted or prevented:

- >5,2 million tonnes industrial waste
- 357 thousand tonnes hazardous waste
- 7.9 million tonnes raw materials
- 9.4 million tonnes industrial water

# UK National IS Program (NISP)

Bio Intelligence Service (2009), Jensen (2011)

# New bill in Oregon to support IS

Bill to develop a plan to identify:

- voluntary IS opportunities
- best practices and technologies
- barriers to adoption

Port of Astoria example:

- looking to bring a byproduct recovery center, innovative wastewater treatment facility
- Aimed at meeting state limits on effluent together
- Focus on **seafood processors**



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# Austin Materials Marketplace

- B2B, 274 companies
- \$372,000 in savings or value creation for participants
- diverted an estimated 45,000 cubic feet from the landfill
- avoided 758 metric tons of carbon dioxide equivalent



# Recycling old wind turbine blades



Circular  
Composite  
Technologies

## Using recycled wind blades in large-format extrusion-based additive manufacturing

### Phase 1 *Initiate!* Successful Prototypes

A wind turbine blade (WTB) at the UMaine ASCC was safely sampled for use in experiments



WTB particles were compounded into pellets, varying levels of wood flour and rPETG



The pellets were used as feedstock for extrusion-based LFAM to make parts for material testing



### Phase 2 *Accelerate!* Full Scale Demonstration

Scale up production to 3000 kg of LFAM feedstock in partnership with Oak Ridge National Lab, and additively manufacture formwork for a precast concrete structure, such as a main bridge structural component



# Allagash Brewing

“Waste to Wares” initiative led by the Manufacturers Association of Maine (MAME)

98% of brewery waste out of landfill  
Recycling CO-OP from partnership to be correctly recycled



PHOTO / TIM GREENWAY

Rob Tod, left, founder of Allagash Brewing, and facilities manager Luke Truman, inside the brewery at 50 Industrial Way in Portland. Allagash, which sells more than 100,000 barrels of beer a year in 17 states plus the District of Columbia, is leading a cross-industry initiative to reduce and repurpose manufacturing waste in Maine.



By Renee Cordes

**A**t Allagash Brewing Co. in Portland, founder Rob Tod speaks as enthusiastically about reducing waste as he does about product expansion at Maine’s largest brewer. It’s known for its Belgian-style ales.



FRESHWATER  
STONE

# Freshwater Stone

Stone Slurry from cutting stone slabs  
and shapes

500-1000 cubic yards of slurry  
annually

Currently stockpiled in a quarry can it  
be used as a cement additive or value  
add additive for other products?



# Ready Seafood



\$ 100K annually to dispose of  
Lobstershell

Shells have desirable compositions  
and can be turned into  
Nutraceuticals or Bioplastics

Research at UMaine to turn  
lobstershell into value add products



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Your ideas,  
please!

## Brief Google Form

Please tell us about 3 wastes in  
your community that you think are  
problematic, and any ideas about  
how to reuse or recycle them!



SCAN ME

[bit.ly/maine-ce-form](https://bit.ly/maine-ce-form)

# Thank you! Questions?

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