KEYNOTE

The middle-out approach to industrial symbiosis development

By Dr. Marian Chertow, Professor and Director of Center for Industrial Ecology at Yale University

The Growing Reach of Industrial Symbiosis

UN environment programme

WORLD BANK GROUP

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

European Commission
CIRCULAR ECONOMY
Closing the loop

United States Business Council for Sustainable Development

UNIDO UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

International Synergies
industrial ecology solutions

ADB ASIAN DEVELOPMENT BANK

Professor Marian Chertow
Director Center for Industrial Ecology
Yale School of the Environment
GreenLab, November 8, 2023

Evolving Definition of Industrial Symbiosis

Industrial symbiosis engages traditionally *separate* industries in **a *collective approach* to competitive advantage** involving *physical exchange* of materials, energy, water, and/or by products.

- Chertow (2000)

HORIZON 2020

Industrial symbiosis (IS) is a systems approach that connects different industrial stakeholders **to leverage underutilised resources in a more integrated and sustainable way.**

- CORALIS project, 2020–2024

Kalundborg Symbiosis, Denmark

Kwinana Industrial Area, Australia

Lanza Tech, Chicago

Puerto Rican IS & supply chains

Devens Eco-Industrial Park, Massachusetts

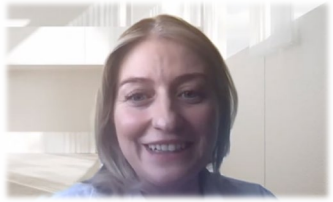
Iceland Ocean Cluster

World Bank Group

Closed Loop Partners, USA

ENV 609: Advanced Industrial Ecology Seminar - Spring '2023
Global Approaches to Industrial Symbiosis

Western Cape IS Program, South Africa



IS efforts in Europe

Israel's national IS program

Korea's National EIP Development Program

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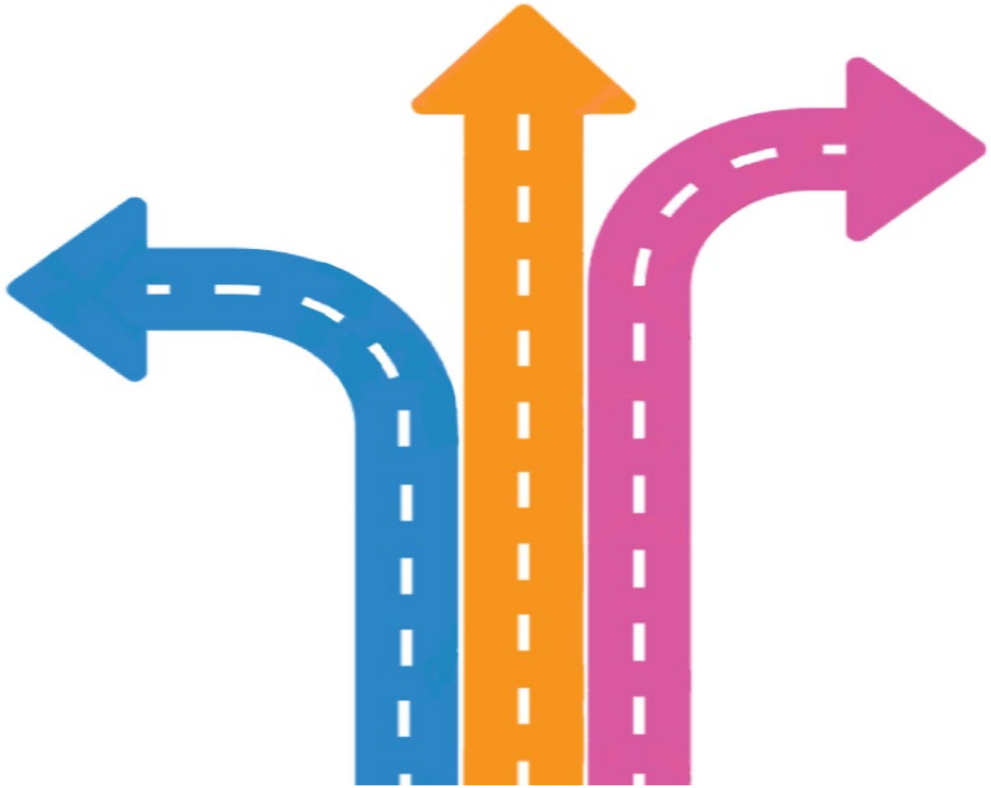


Six dynamics currently identified

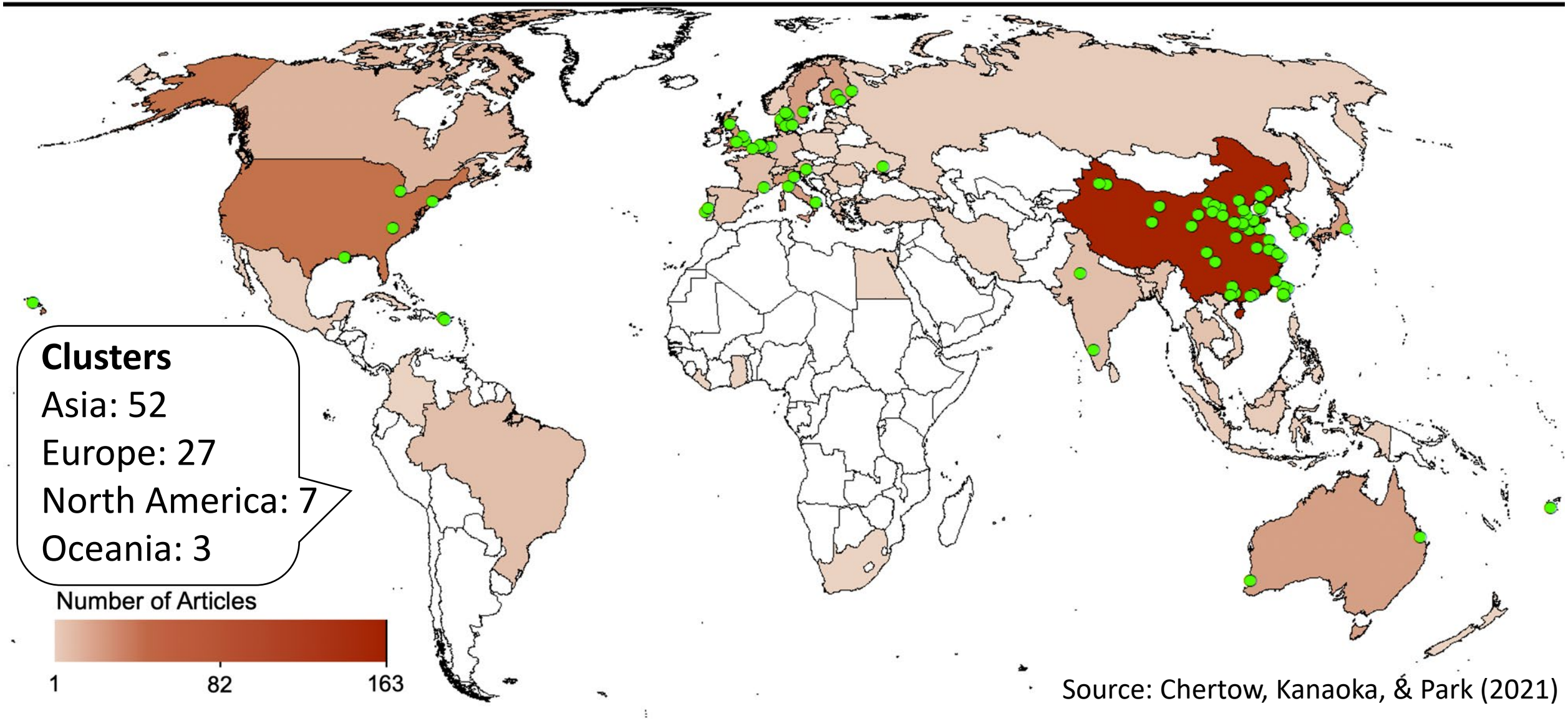
1. Self-organization
2. Organizational boundary change

3a. Facilitation - brokerage

3b. Facilitation - collective learning

4. Pilot facilitation and dissemination
5. Government planning
6. Eco-cluster Development

We catalogued 89 industrial clusters in 21 countries that were identified in journal articles on industrial symbiosis (1995–2018)



Source: Chertow, Kanaoka, & Park (2021)

Annual Industrial Symbiosis Research Symposium

Year	Hosting location	Host or contact person
2004	New Haven, Connecticut, **USA**	Marian Chertow
2005	Stockholm, **Sweden**	Noel Jacobsen
2006	Birmingham, **UK**	Peter Laybourn
2007	Toronto, **Canada**	Ray Côté
2008	Devens, Massachusetts, **USA**	Peter Lowitt
2009	Kalundborg, **Denmark**	Jørgen Christensen
2010	Kawasaki, **Japan**	Tsuyoshi Fujita with China, Korea, Japan sponsorship
2011	San Francisco, California, **USA**	Marian Chertow
2012	Tianjin, **China**	Shi Han, Yuyan Song
2013	Ulsan, **South Korea**	Hung-Suck Park
2014	Melbourne, **Australia**	Robin Branson, Biji Kurup
2015	Lausanne, **Switzerland**	Guillaume Massard, Suren Erkman
2016	Devens, Massachusetts, **USA**	Peter Lowitt
2017	Chicago, Illinois, **USA**	Weslynne Ashton
2018	Cartago, **Costa Rica**	Jose Alfaro, Graham Aid
2019	Beijing, **China**	Graham Aid, Chang Yu with China sponsorship
2020–2022	Postponed due to COVID-19	
2023	Leiden, **Netherlands**	Graham Aid

Translating knowledge into impact

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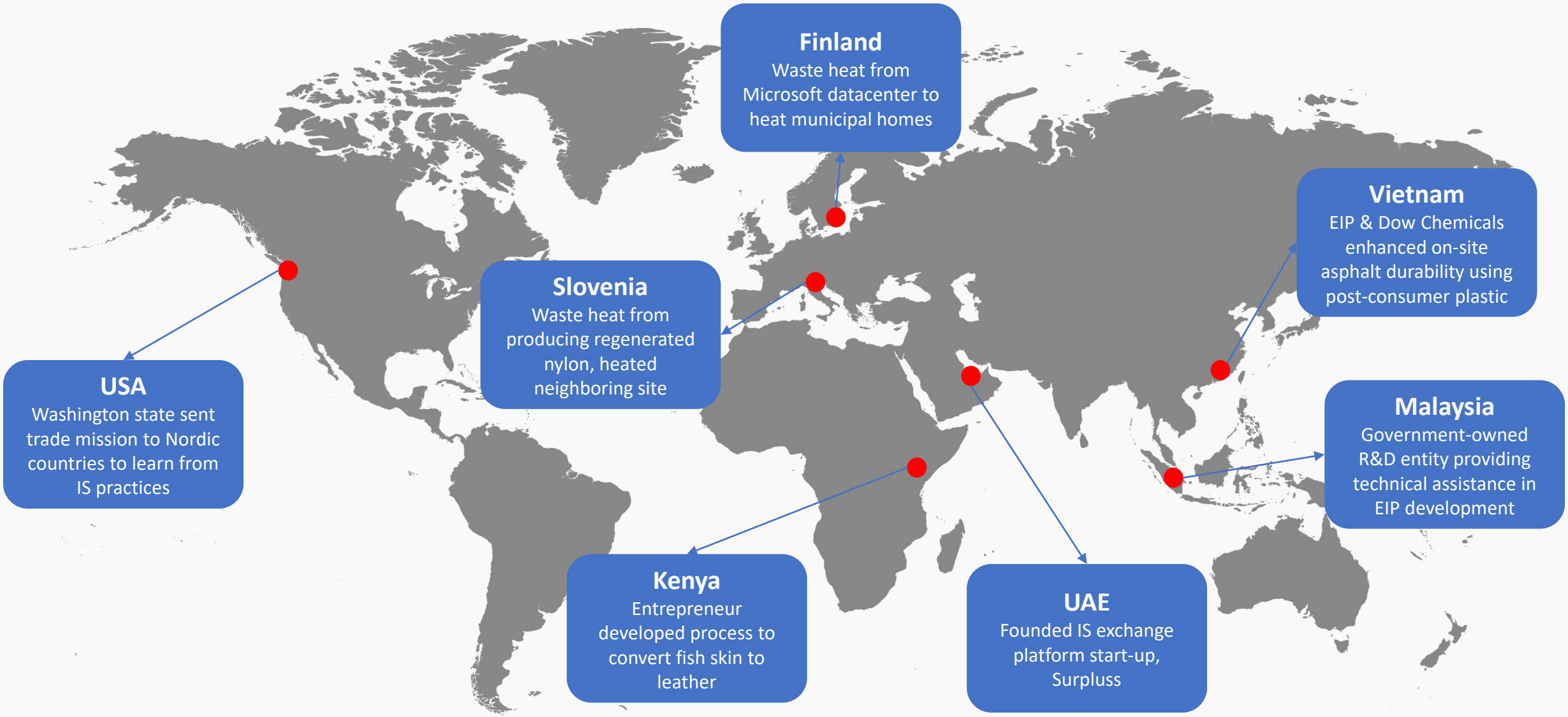
Center for Industrial Ecology

THE WORLD BANK

Collaborations:

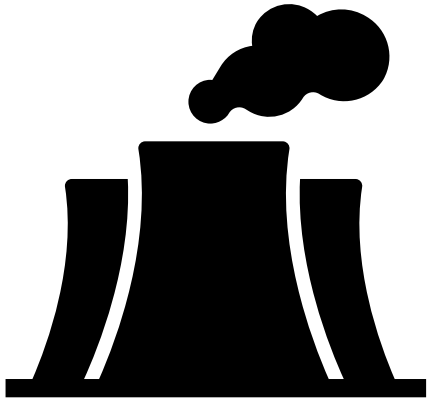
- Memorandum of Understanding
- Creating online, open source IS data platform for use by industrial parks
- Advising on IS implementation in Morocco, Bangladesh, and more
- Publication in progress - Angel Hakim, et al. Data-limited industrial symbiosis: Developing methodology and application from Morocco

Google Alerts: Identify IS activity beyond academia

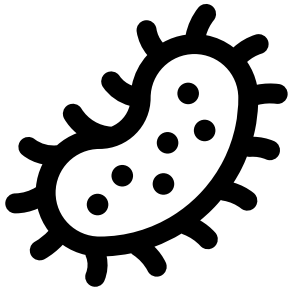


The Future of Industrial Symbiosis (?)

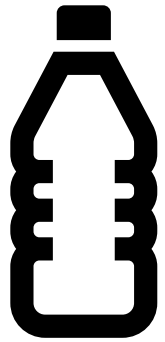
Waste input → **Process** → **Output**



OFFGAS
STEEL MILL



MICROBE
FERMENTATION



ETHANOL

LanzaTech