TIEEP

TEXAS INDUSTRIAL ENERGY EFFICIENCY PROGRAM

Water Forum

The Nexus of Water and Energy Conservation

Tools and Techniques for Assessing Sustainability in Engineering Design

Dr. Andrew Shaw,
Black & Veatch

SECO State Energy Conservation Office

UNIVERSITY of HOUSTON
UH ENERGY

Tools and Techniques for Assessing Sustainability in Engineering Design

Dr. Andrew Shaw PE, BCEE, ENV SP

Global Practice & Technology Leader

Black & Veatch Today

- 12,000+ professionals in 120+ global offices
- 250+ in Houston
- 8th largest employee-owned ESOP in the United States
- Projects in 100+ countries on six continents
- $4.3 billion in 2022 revenue

A pioneering spirit as **a partner of choice for disruptive, first of a kind solutions.**

Our Purpose: **Building a World of Difference**

Our Vision: **THE Leader in Sustainable Infrastructure**

#13 Top 500 Design Firms

#2 Power

#6 Telecom

#8 Water

#2 Solar Power

#8 Refineries & Petrochemical Plants

#1 Hydrogen EPC*

#2 Towers & Antennae

#42 In Top 400 Contractors

Current Engineering News-Record rankings.

** Reuters Events Top 100 Innovators in Hydrogen 2023 - EPC*

Sustainable Infrastructure…?

Sustainable Infrastructure…
Supports the Economy

Sustainable Infrastructure…
Enhances Quality of Life

Sustainable Infrastructure…

Considers Environmental Impacts

Sustainable Infrastructure…
Has a Local Focus

Sustainable Infrastructure…
Takes a Long-Term Perspective

Sustainable Infrastructure…

??????

Tools & Techniques

1. Envision
2. Life Cycle Assessment (LCA)

ENVISION™

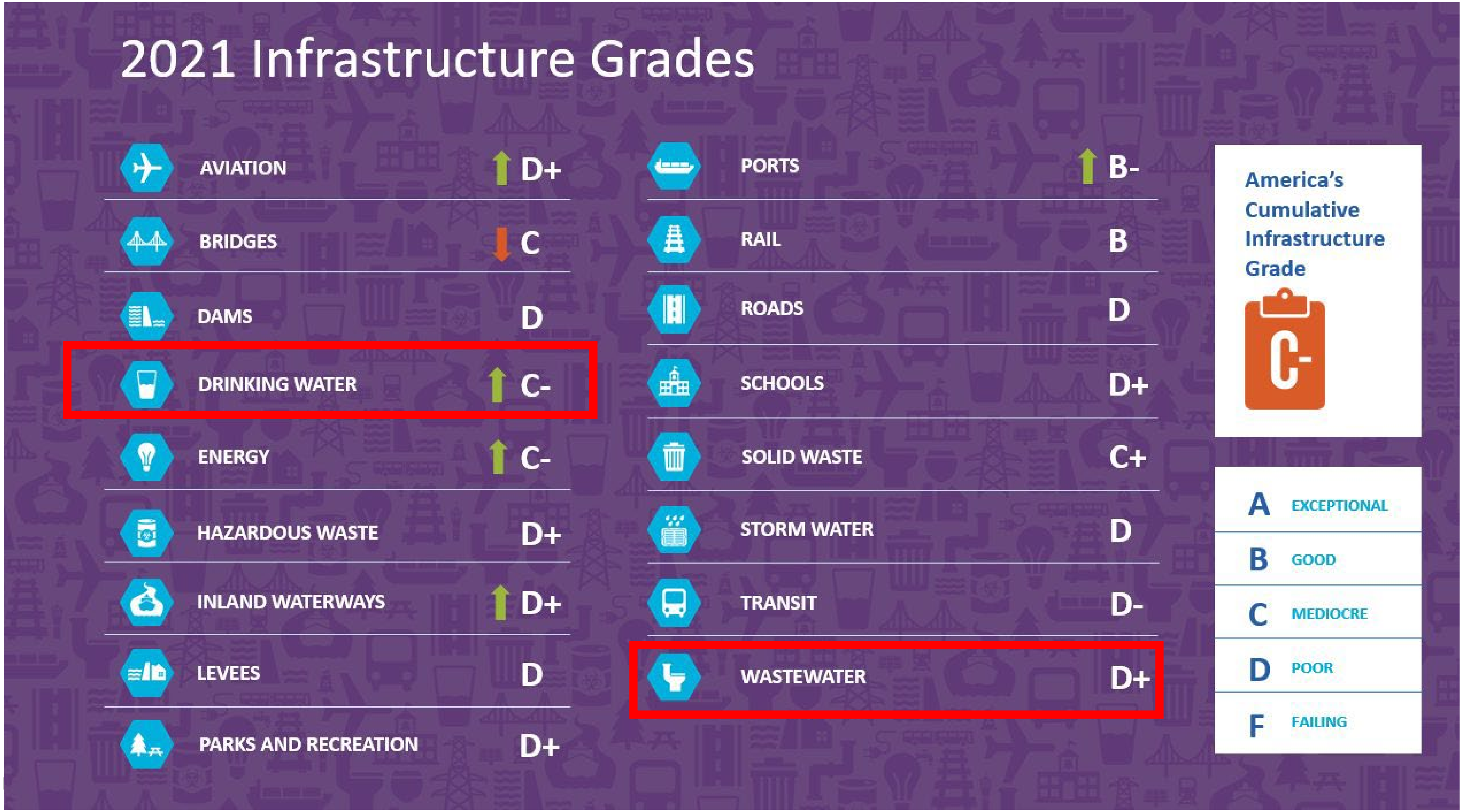
Introducing Envision

Envision is a blueprint for fundamental change in infrastructure development.

- Enables a **thorough examination** of the sustainability and resiliency of infrastructure projects
- Provides **practical guidance** on how to improve performance
- Drives **better project management**

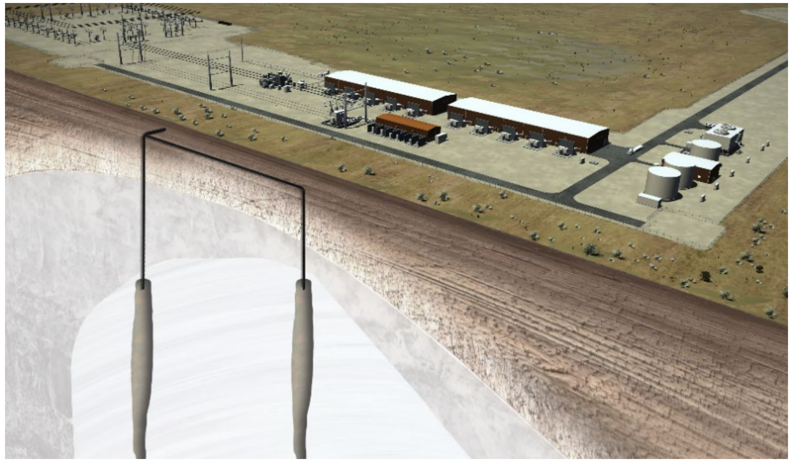
Institute for Sustainable Infrastructure

ASCE's Report Card for America's Infrastructure



America’s Infrastructure Today

The Future of Infrastructure

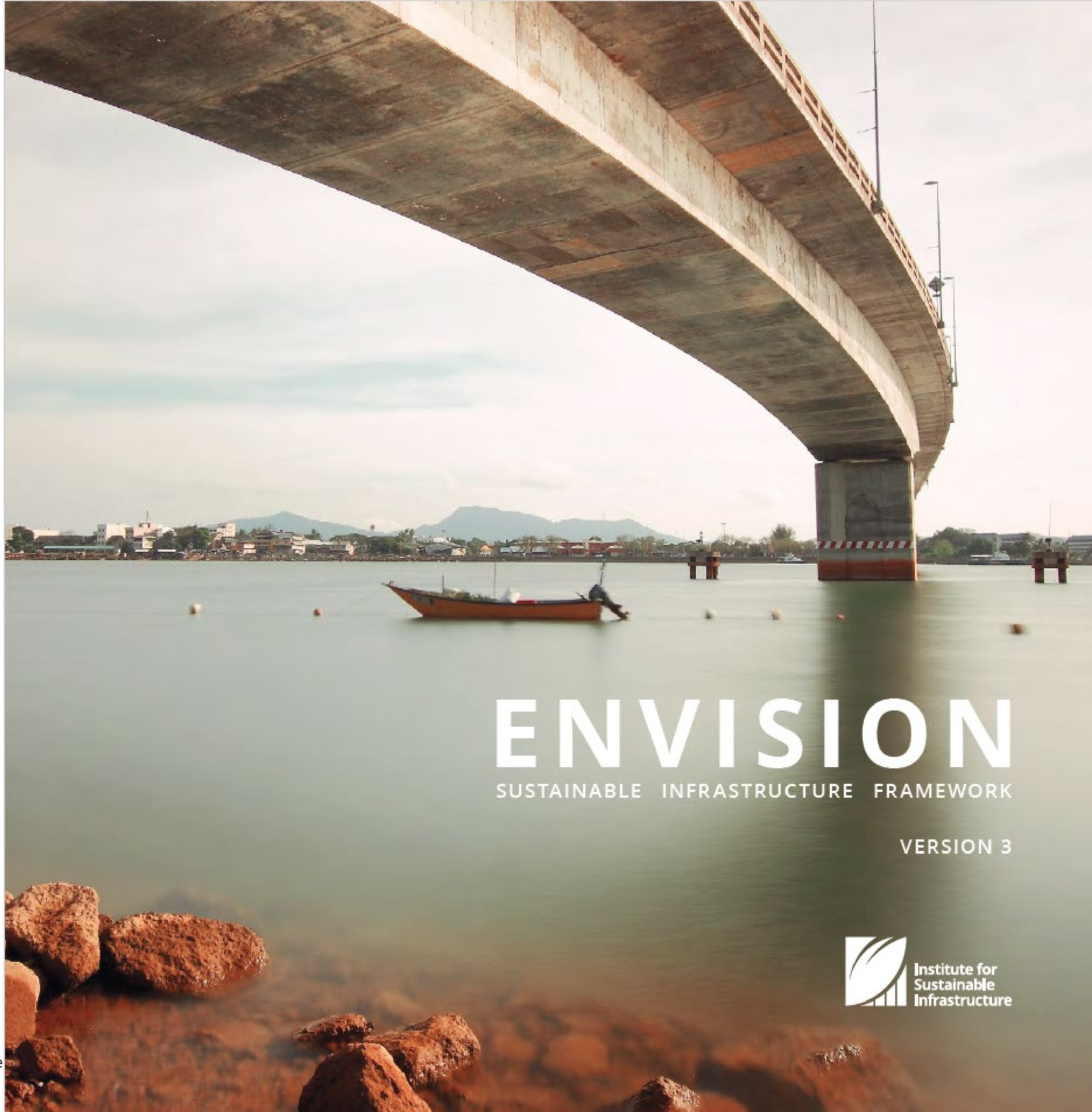


Envision™

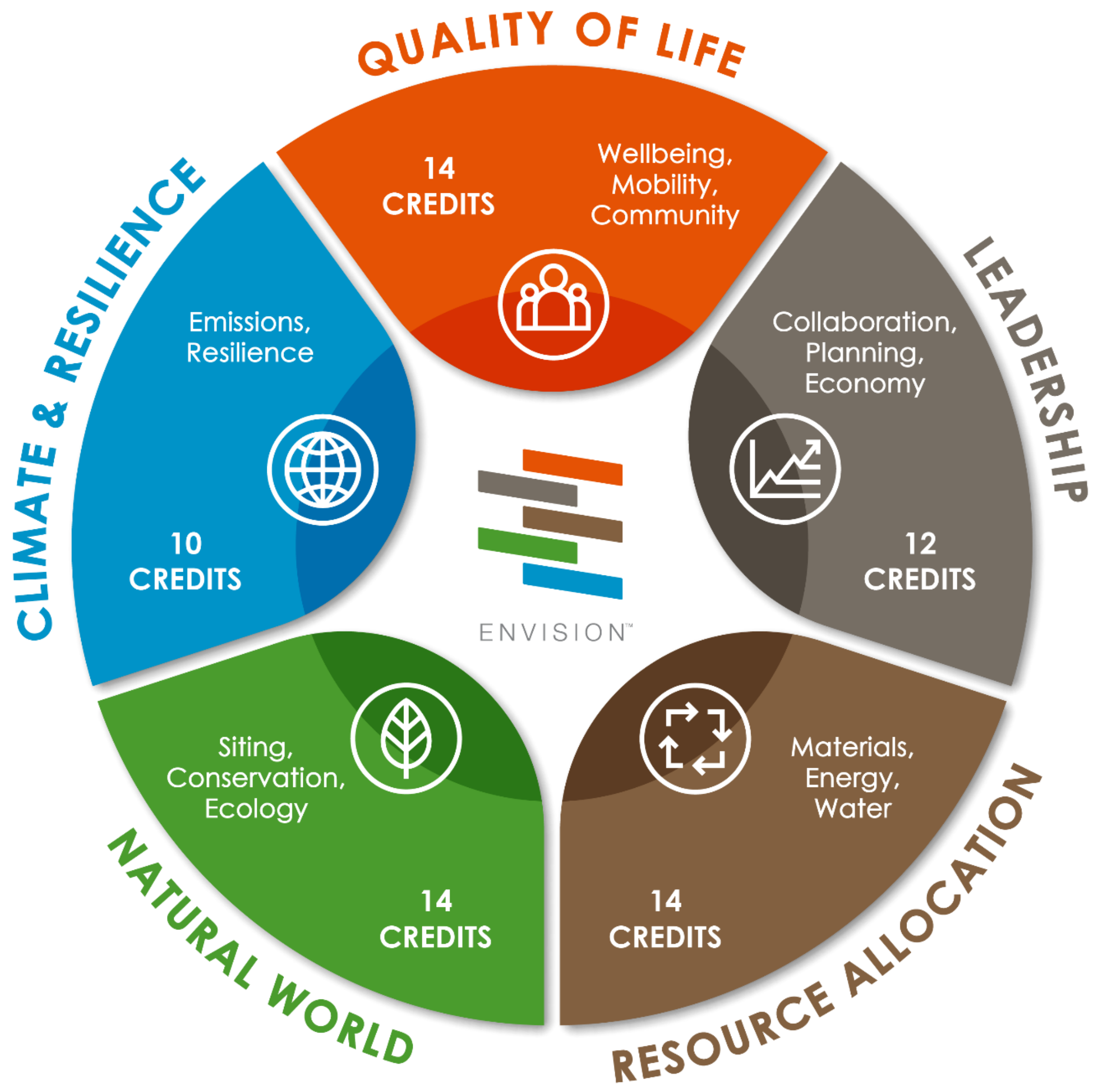
- Institute for Sustainable Infrastructure (ISI)
- Like LEED for non-building, Infrastructure
- Launched in 2013

Envision is Backed by Major National Member Organizations

The Institute for Sustainable Infrastructure is a not-for-profit education and research organization founded by the American Public Works Association, the American Council of Engineering Companies and the American Society of Civil Engineers.



5 Categories of Sustainability Indicators



64 Credits (Sustainability & Resilience Indicators)

Quality Of Life
14 Credits

WELLBEING
- **QL1.1** Improve Community Quality of Life
- **QL1.2** Enhance Public Health & Safety
- **QL1.3** Improve Construction Safety
- **QL1.4** Minimize Noise & Vibration
- **QL1.5** Minimize Light Pollution
- **QL1.6** Minimize Construction Impacts

MOBILITY
- **QL2.1** Improve Community Mobility & Access
- **QL2.2** Encourage Sustainable Transportation
- **QL2.3** Improve Access & Wayfinding

COMMUNITY
- **QL3.1** Advance Equity & Social Justice
- **QL3.2** Preserve Historic & Cultural Resources
- **QL3.3** Enhance Views & Local Character
- **QL3.4** Enhance Public Space & Amenities

- **QL0.0** Innovate or Exceed Credit Requirements

Leadership
12 Credits

COLLABORATION
- **LD1.1** Provide Effective Leadership & Commitment
- **LD1.2** Foster Collaboration & Teamwork
- **LD1.3** Provide for Stakeholder Involvement
- **LD1.4** Pursue Byproduct Synergies

PLANNING
- **LD2.1** Establish a Sustainability Management Plan
- **LD2.2** Plan for Sustainable Communities
- **LD2.3** Plan for Long-Term Monitoring & Maintenance
- **LD2.4** Plan for End-of-Life

ECONOMY
- **LD3.1** Stimulate Economic Prosperity & Development
- **LD3.2** Develop Local Skills & Capabilities
- **LD3.3** Conduct a Life-Cycle Economic Evaluation

- **LD0.0** Innovate or Exceed Credit Requirements

Resource Allocation
14 Credits

MATERIALS
- **RA1.1** Support Sustainable Procurement Practices
- **RA1.2** Use Recycled Materials
- **RA1.3** Reduce Operational Waste
- **RA1.4** Reduce Construction Waste
- **RA1.5** Balance Earthwork On Site

ENERGY
- **RA2.1** Reduce Operational Energy Consumption
- **RA2.2** Reduce Construction Energy Consumption
- **RA2.3** Use Renewable Energy
- **RA2.4** Commission & Monitor Energy Systems

WATER
- **RA3.1** Preserve Water Resources
- **RA3.2** Reduce Operational Water Consumption
- **RA3.3** Reduce Construction Water Consumption
- **RA3.4** Monitor Water Systems

- **RA0.0** Innovate or Exceed Credit Requirements

Natural World
14 Credits

SITING
- **NW1.1** Preserve Sites of High Ecological Value
- **NW1.2** Provide Wetland & Surface Water Buffers
- **NW1.3** Preserve Prime Farmland
- **NW1.4** Preserve Undeveloped Land

CONSERVATION
- **NW2.1** Reclaim Brownfields
- **NW2.2** Manage Stormwater
- **NW2.3** Reduce Pesticide & Fertilizer Impacts
- **NW2.4** Protect Surface & Groundwater Quality

ECOLOGY
- **NW3.1** Enhance Functional Habitats
- **NW3.2** Enhance Wetland & Surface Water Functions
- **NW3.3** Maintain Floodplain Functions
- **NW3.4** Control Invasive Species
- **NW3.5** Protect Soil Health

- **NW0.0** Innovate or Exceed Credit Requirements

Climate and Resilience
10 Credits

EMISSIONS
- **CR1.1** Reduce Net Embodied Carbon
- **CR1.2** Reduce Greenhouse Gas Emissions
- **CR1.3** Reduce Air Pollutant Emissions

RESILIENCE
- **CR2.1** Avoid Unsuitable Development
- **CR2.2** Assess Climate Change Vulnerability
- **CR2.3** Evaluate Risk & Resilience
- **CR2.4** Establish Resilience Goals and Strategies
- **CR2.5** Maximize Resilience
- **CR2.6** Improve Infrastructure Integration

- **CR0.0** Innovate or Exceed Credit Requirements

Envision Credit Detail

QUALITY OF LIFE: WELLBEING

QL1.1 Improve Community Quality of Life

26
POINTS

INTENT
Improve the net quality of life of all communities affected by the project and mitigate negative impacts to communities.

METRIC
Measures taken to assess community needs and improve quality of life while minimizing negative impacts.

LEVELS OF ACHIEVEMENT

IMPROVED	ENHANCED	SUPERIOR	CONSERVING	RESTORATIVE
A + B	A + B + C + D	A + B + C + D + E	A + B + C + D + E + F	A + B + C + D + E + F + G
(2) Community Considerations	(5) Community Linkages	(10) Broad Community Alignment	(20) Holistic Assessment & Collaboration	(26) Protecting The Future

(A) The project team identifies and takes into account community needs, goals, and issues. For example, the project team has located and reviewed the most recent community planning information and assessed relevant community needs, goals, and/or issues.

(B) The project meets or supports community needs and/or goals.

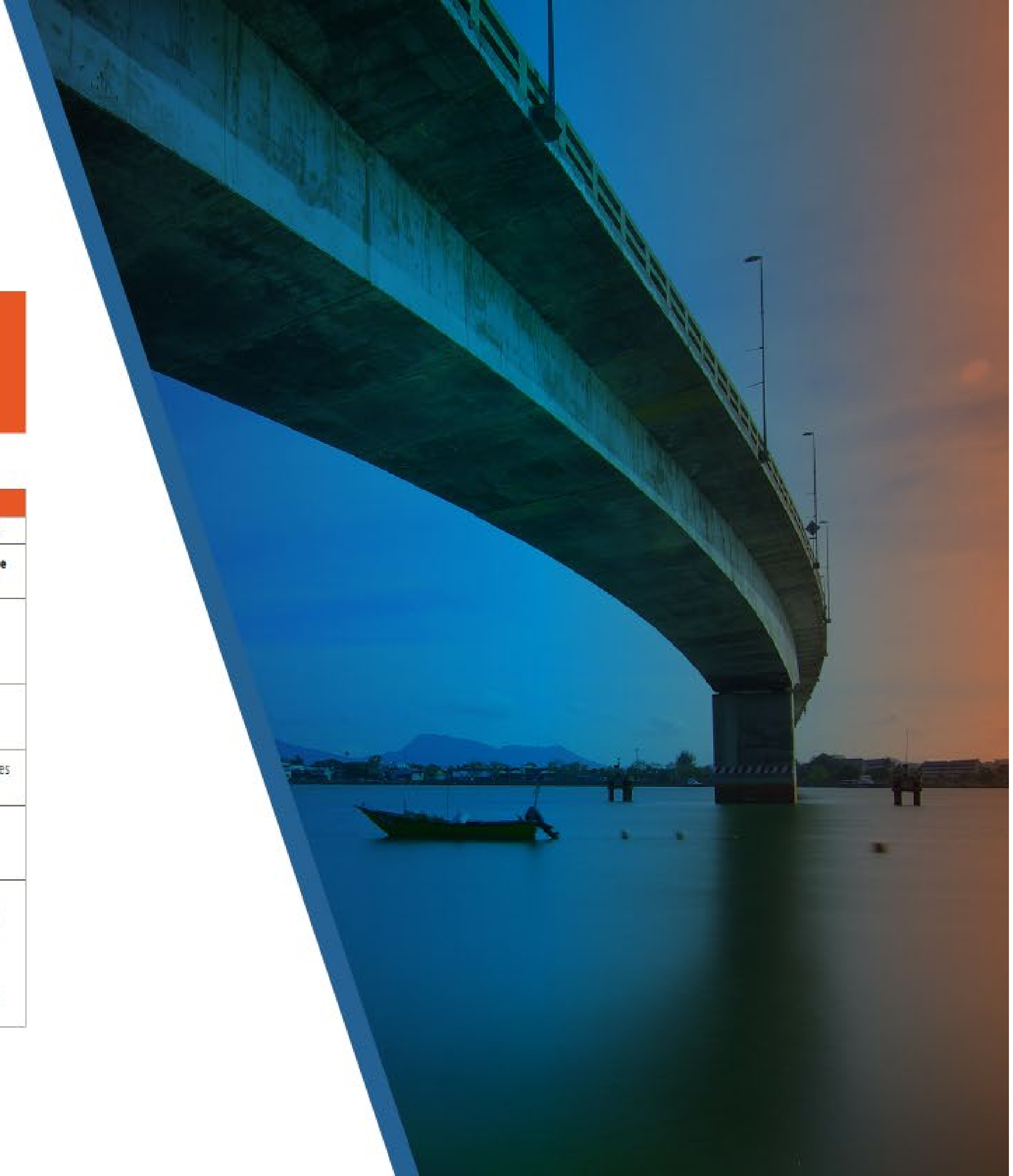
(C) The project assesses the social impacts it will have on the host and affected communities' quality of life.

(D) The affected communities are meaningfully engaged in identifying how the project supports community needs and/or goals.

(E) Based on the social assessment, potential negative impacts on the host or nearby affected communities are mitigated following a hierarchy that prioritizes avoidance, minimization, restoration, and offsetting.

(F) Community satisfaction is demonstrated by feedback from the stakeholder engagement process verifying actions taken in criteria A, B, C, and D.

(G) The project proactively addresses trends in changing social, economic, and/or environmental conditions within the community in order to ensure a high quality of life over the long term.



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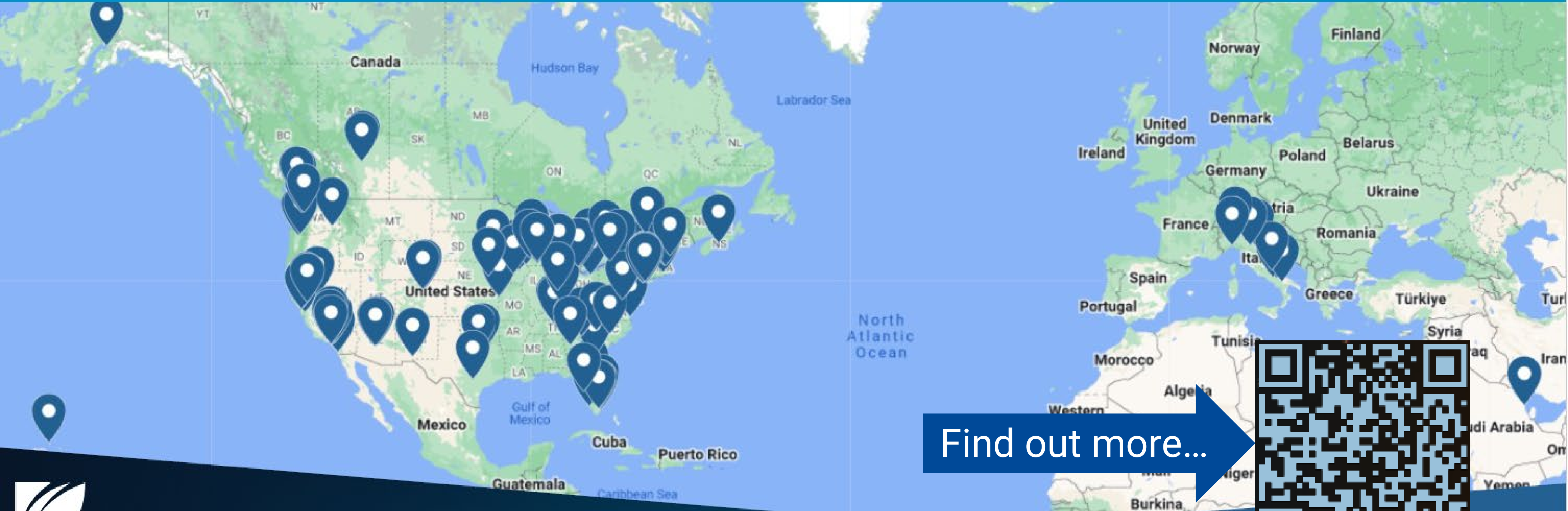
Envision Use

- 165+ verified projects, totaling ~$130 billion
- 185+ projects in registration, totaling ~$120 billion
- 9,250+ credentialed professionals
- 650+ organizational members

**as of March 31, 2024*

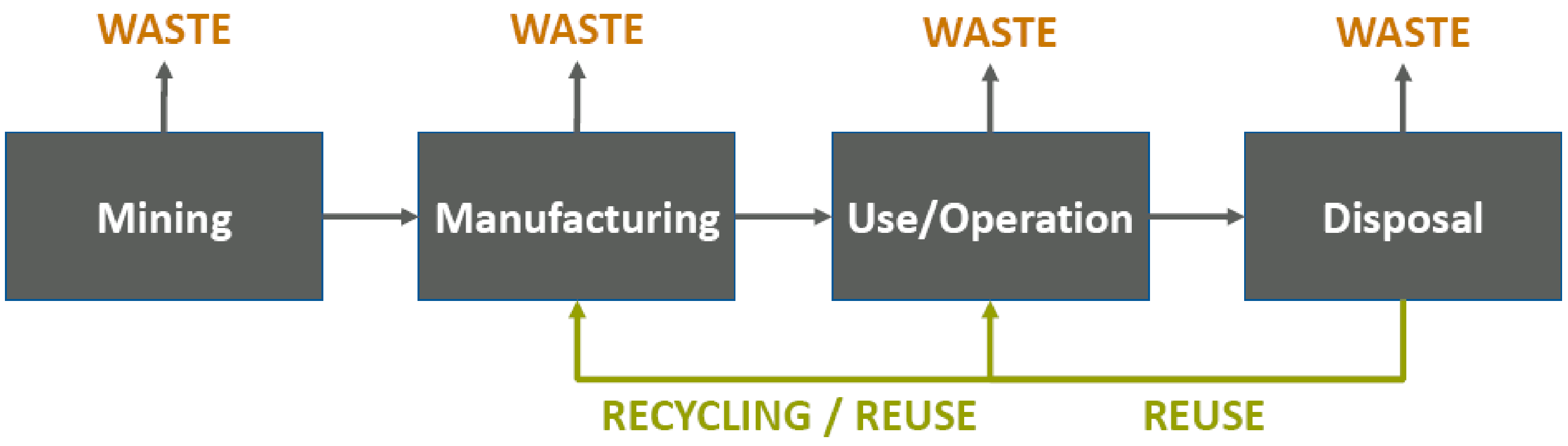


Find out more...

Institute for Sustainable Infrastructure

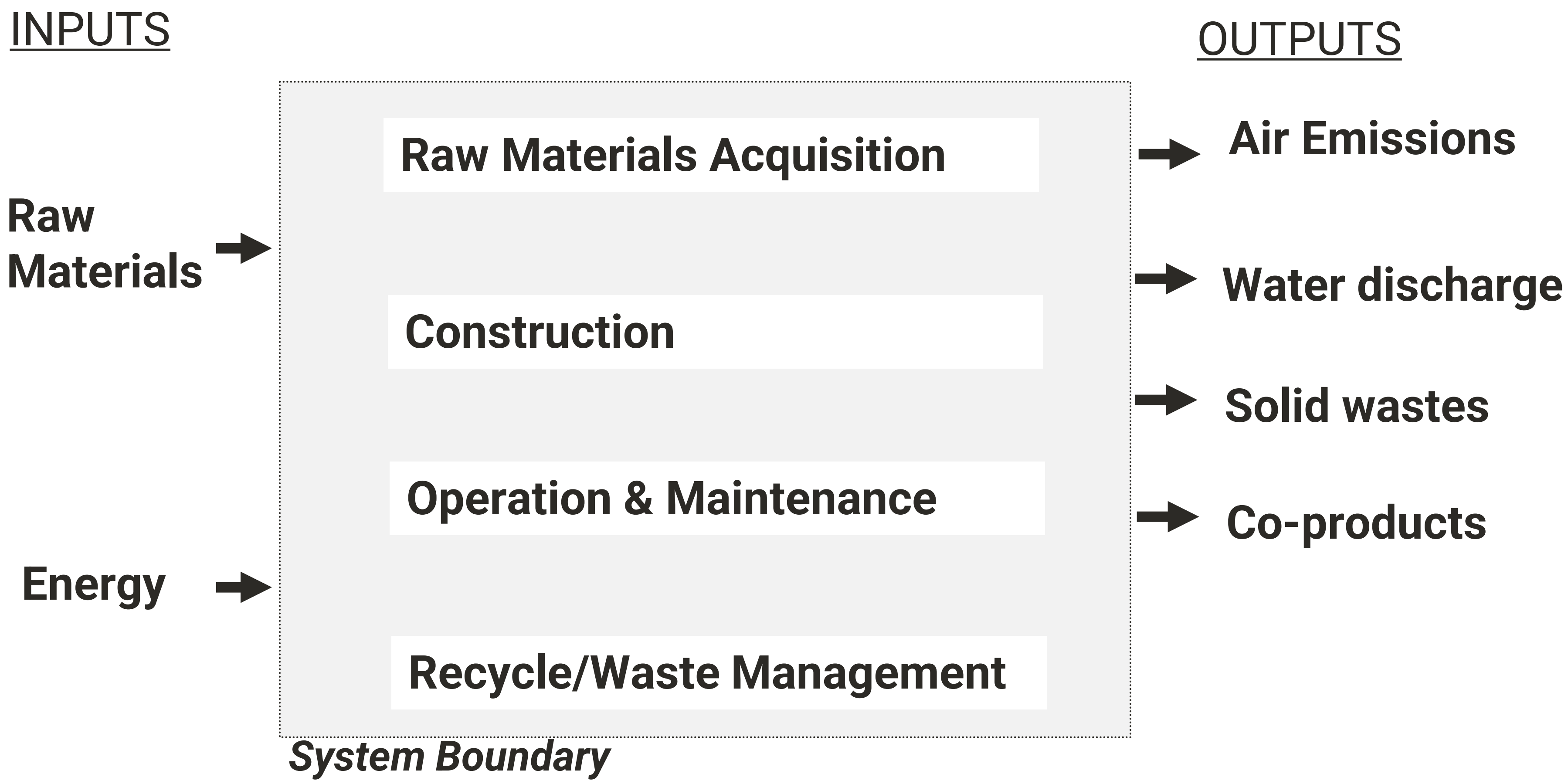
What is LCA?

Life Cycle Assessment Principle

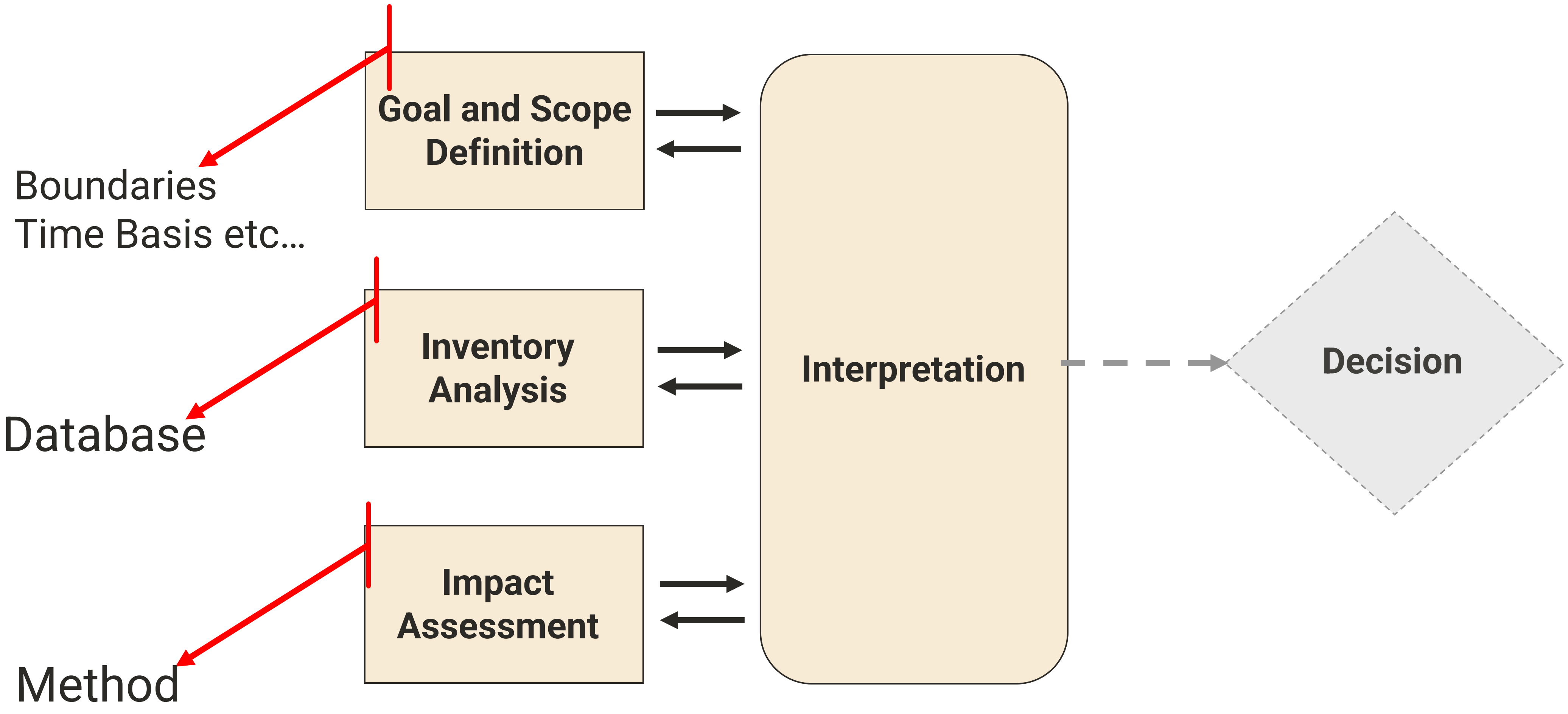


- Track Mass Flows using a Broad "Holistic" Approach
- Track Energy Use and Tie this to Materials (e.g. Fossil Fuels)
- Assess *Potential* Impact of Constituent Mass Loads and Energy Under Different Categories
- The Ultimate Mass Balance?!

LCA Inputs/Outputs Schematic



Life Cycle Assessment (LCA) – ISO 14000 Series



LCA Software

SimaPro

- https://simapro.com/

GaBi

- https://gabi.sphera.com/america/index/

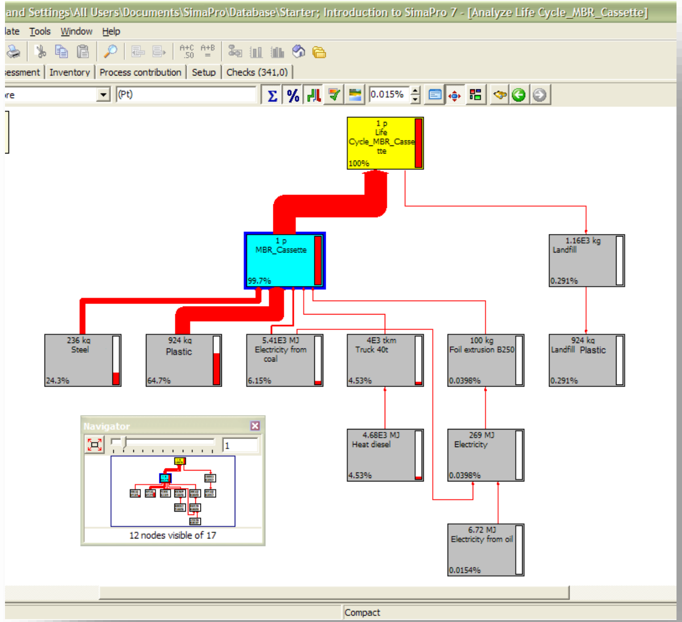
OpenLCA

- http://www.openlca.org/

Multiple Databases:
ecoinvent v.2, US LCI, ELCD, US Input Output, EU and Danish Input Output, Dutch Input Output, LCA Food, Industry data v.2.

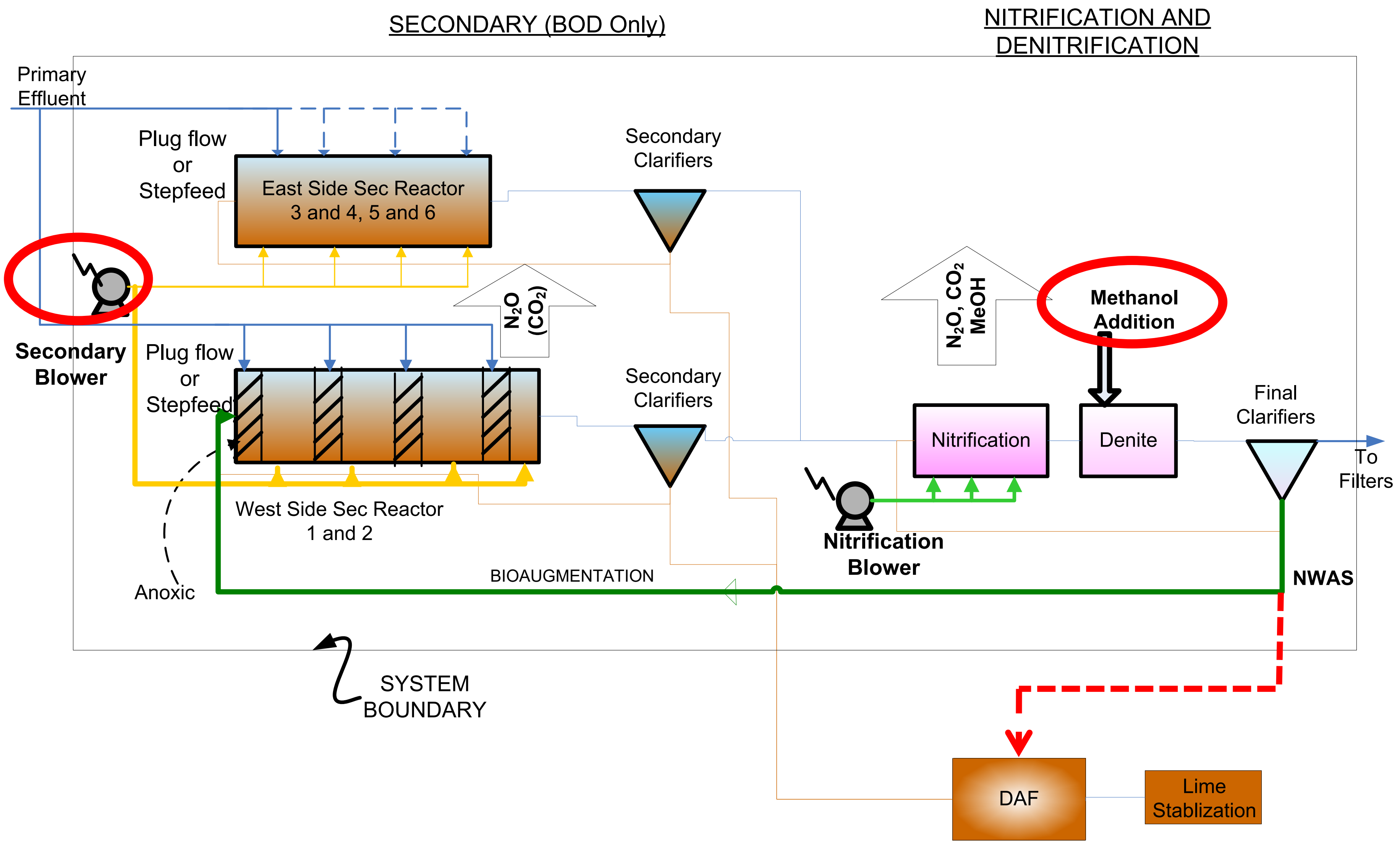
Multiple Assessment Methods:
ReCiPe, Eco-indicator 99, USEtox, IPCC 2007, EPD, Impact 2002+, CML-IA, Traci 2, BEES, Ecological Footprint, EDIP 2003, Ecological scarcity 2006, EPS 2000, Greenhouse Gas Protocol and others.

LCA Example

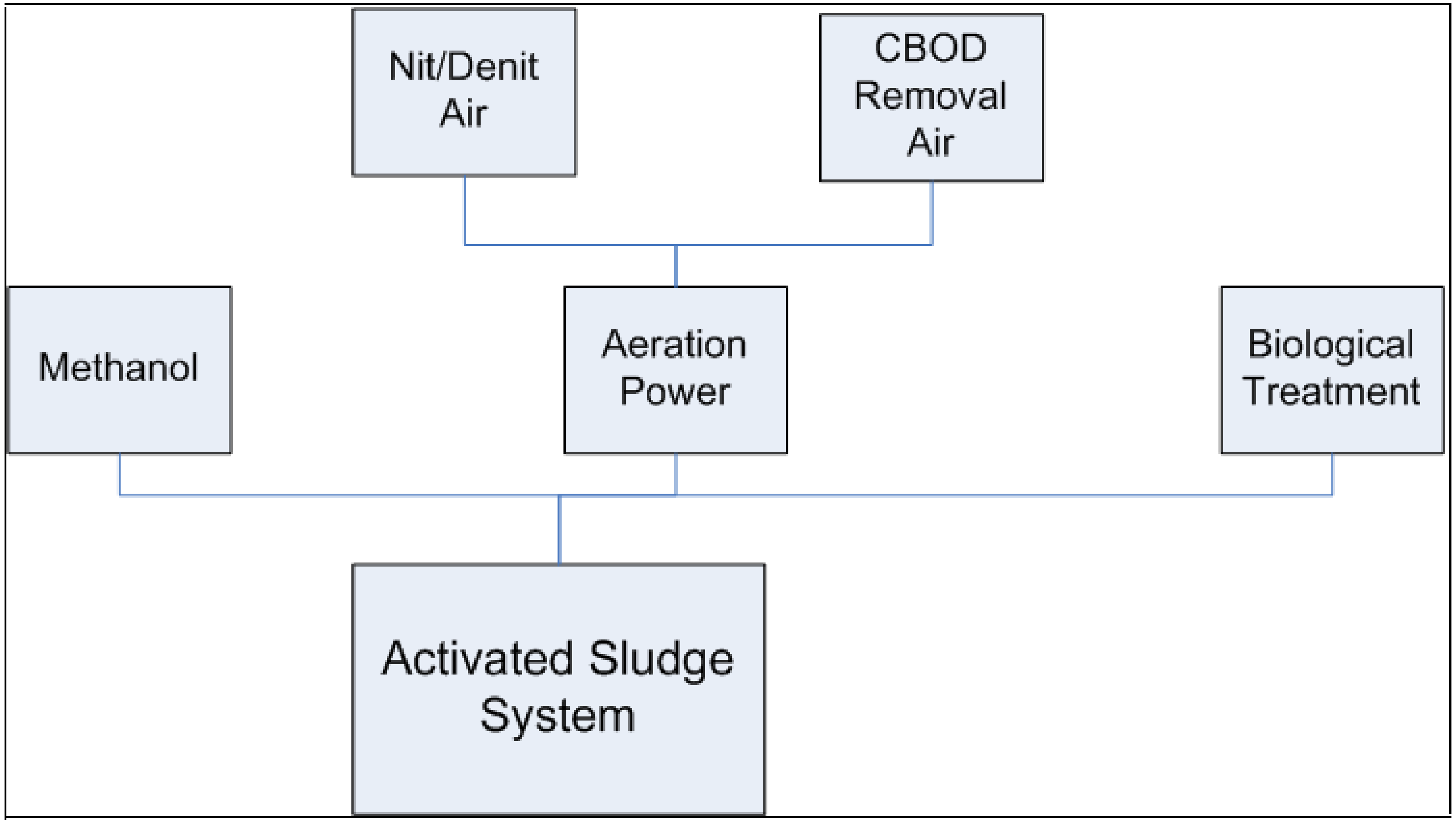


Process contribution
Checks (341,0)
1 p Life Cycle_MBR_Cassette
100%
1 p MBR_Cassette
99.7%
1.16E3 kg Landfill
0.291%
236 kg Steel
24.3%
924 kg Plastic
64.7%
5.41E3 MJ Electricity from coal
6.15%
4E3 tkm Truck 40t
4.53%
100 kg Foil extrusion B250
0.0398%
924 kg Landfill Plastic
0.291%
4.68E3 MJ Heat diesel
4.53%
269 MJ Electricity
0.0398%
6.72 MJ Electricity from oil
0.0154%
Navigator
12 nodes visible of 17
Compact

Case Study: Blue Plains AWTP Bioaugmentation or Not?



Inventory – System Components



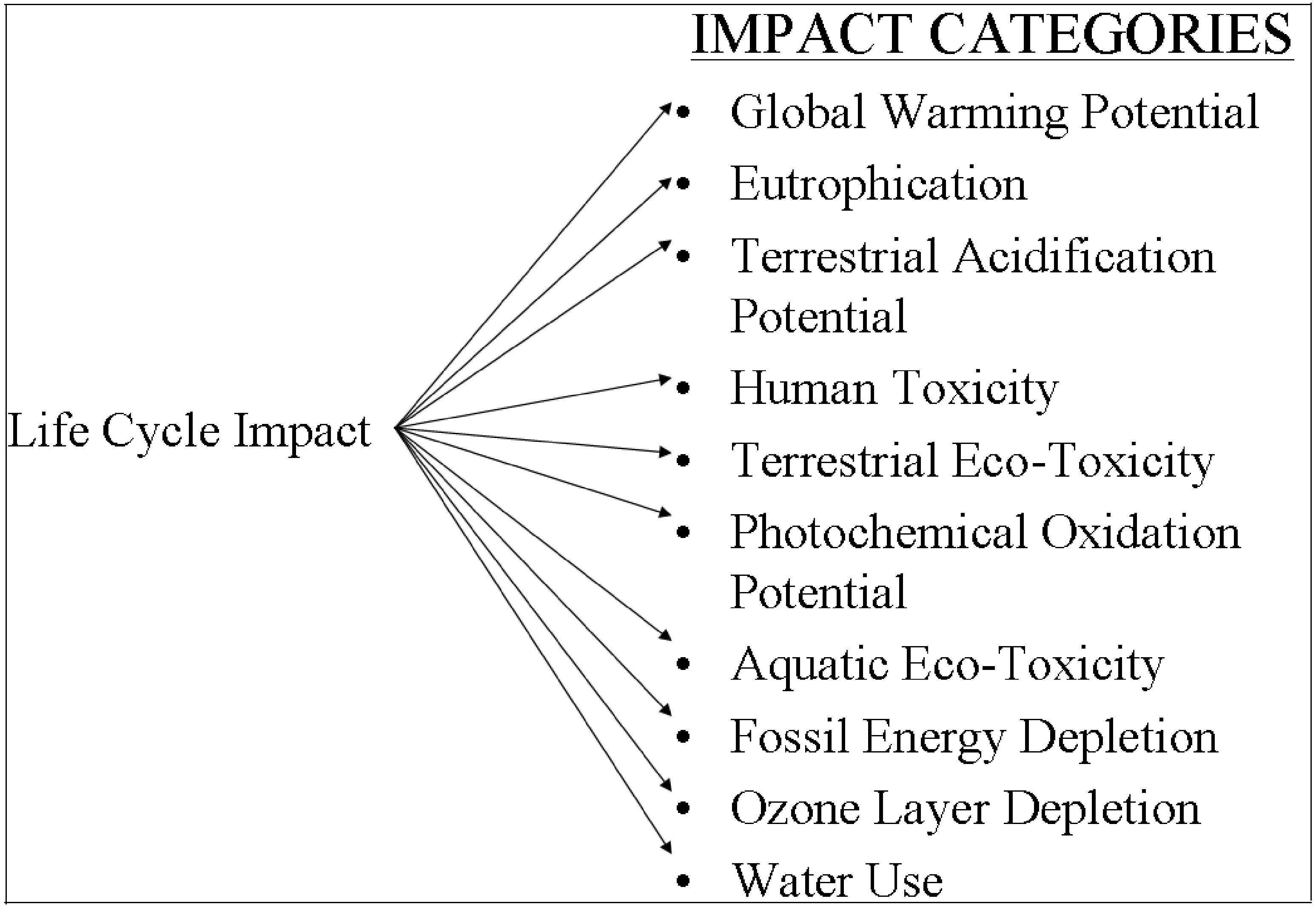
Inventory - Data

	BioAugmentation	No BioAugmentation
Methanol Use (gal/year)	3.57×10^7	4.71×10^7
Aeration Power		
Nit/Denit Air (kWh/yr)	2,590,909	3,465,909
CBOD Removal Air (kWh/yr)	39,409,091	33,272,727
Biological Treatment		
Emissions to Air		
N_2O (kg/yr)	0.117×10^6	0.117×10^6
Methanol (lb/yr)	2000	2000
CO_2 (lb/yr)	8.11×10^4	1.06×10^5
Effluent Emissions		
Nitrogen (kg/m^3)	4.3×10^{-3}	4.3×10^{-3}
Phosphorus (kg/m^3)	0.8×10^{-4}	0.8×10^{-4}
N_2O (kg/m^3)	1.4×10^{-5}	1.4×10^{-5}
Nickel (kg/m^3)	5.03×10^{-6}	5.03×10^{-6}
Copper (kg/m^3)	3.9×10^{-6}	3.9×10^{-6}
Lead (kg/m^3)	2.6×10^{-6}	2.6×10^{-6}
Molybdenum (kg/m^3)	7.18×10^{-6}	7.18×10^{-6}
Cadmium (kg/m^3)	2.5×10^{-7}	2.5×10^{-7}
Chloroform (kg/m^3)	3.52×10^{-6}	3.52×10^{-6}
Chloro dibromo methane (kg/m^3)	1.35×10^{-6}	1.35×10^{-6}
Bromo dichloro methane (kg/m^3)	3.25×10^{-6}	3.25×10^{-6}

Inventory – Data (Electricity Mix)

Coal	53.5%
Nuclear	34.7%
Natural Gas	6.9%
Hydropower	0.9%
Oil	0.3%
Wind Power	0.5%
Cogeneration- Wood	2%
Cogeneration- Biogas	1.2%
*Electricity mix per kilowatt-hour of power from Pepco website: http://www.pepco.com/_res/documents/pepcomdfuelmix6_09.pdf	

Impact Assessment Method

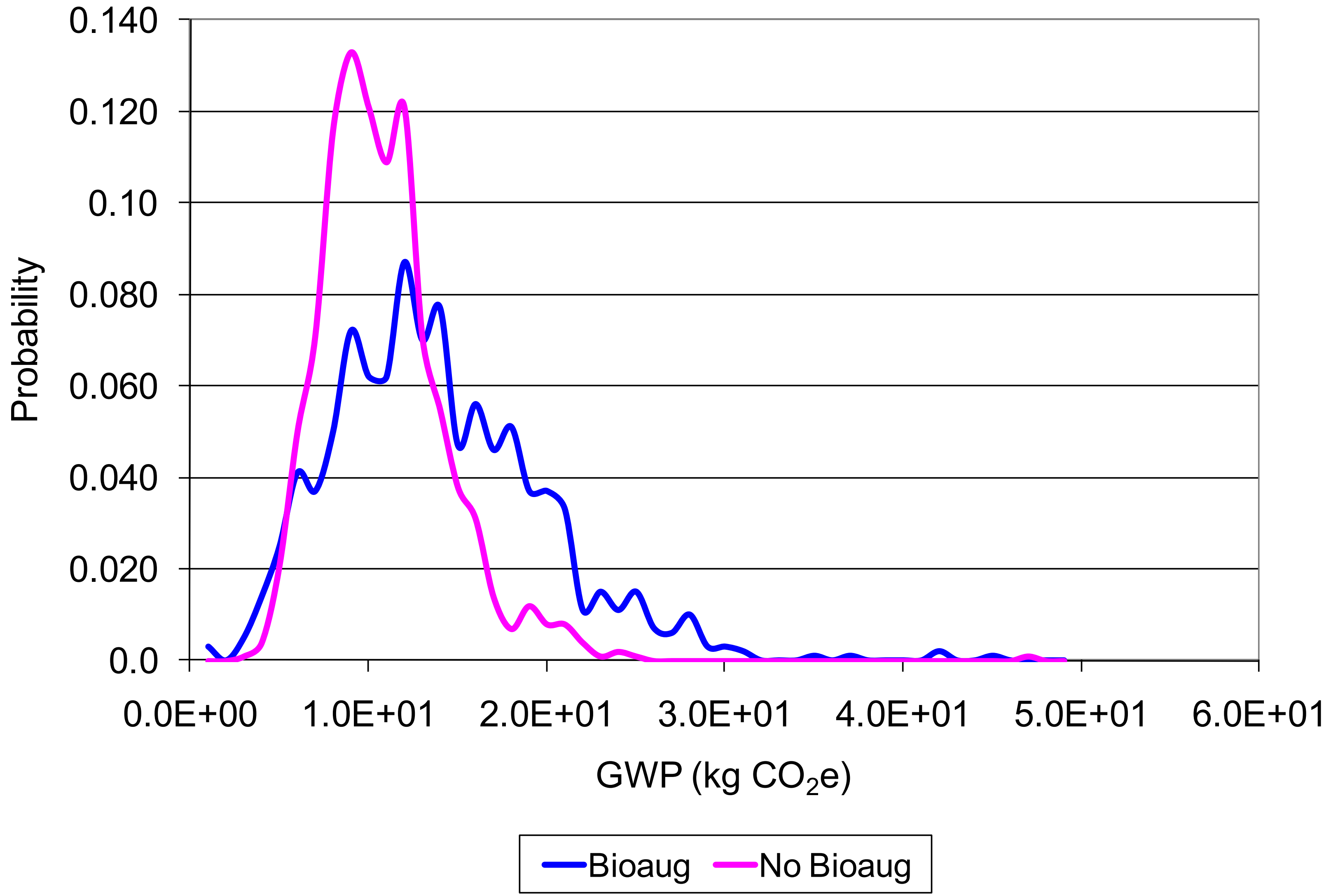


Impact Assessment - Damage

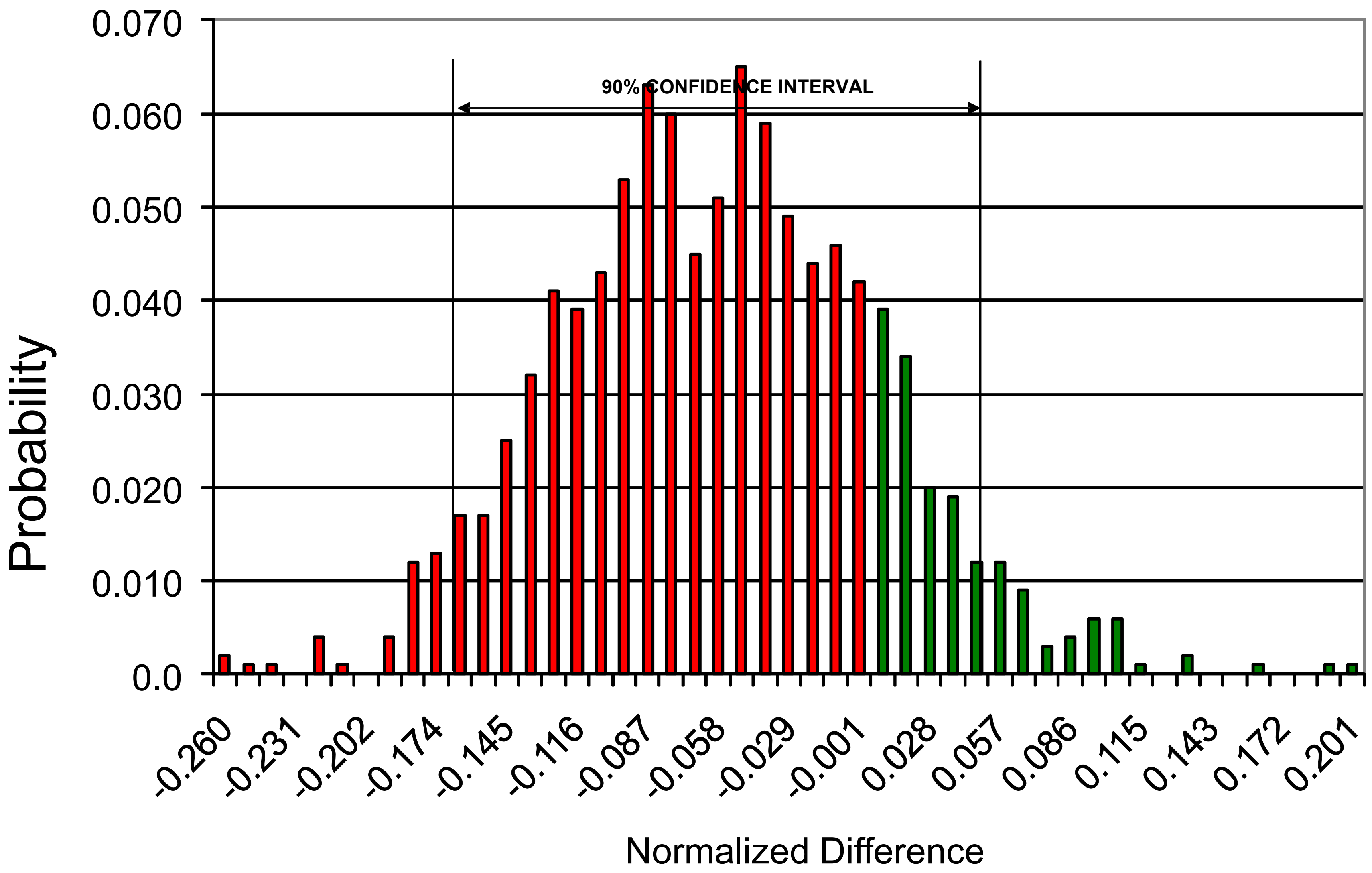
Potential Impact of Various Categories					
Damage Category	**Unit**	**Bioaugmentation**	**No Bioaugmentation**	**Difference***	**Percentage* Difference**
Carcinogens	kg C_2H_3Cl eq	1.18×10^6	1.16×10^6	0.02×10^6	1.7%
Non- Carcinogens	kg C_2H_3Cl eq	7.94×10^5	7.48×10^5	0.46×10^5	5.8%
Ozone Layer Depletion	kg CFC-11 eq	4.05	4.77	**-0.72**	**17.8%**
Photochemical Oxidation	kg C_2H_4 eq	8540	9980	**-1440**	**16.9%**
Aquatic Ecotoxicity	kg TEG eq-water	5.03×10^{10}	5.02×10^{10}	0.01×10^{10}	0.2%
Terrestrial Ecotoxicity	kg TEG eq-soil	6.61×10^8	6.43×10^8	0.18×10^8	2.7%
Terrestrial acid/nutri	kg SO_2 eq	6.26×10^5	6.01×10^5	0.25×10^5	4.0%
Eutrophication- P	kg P	3.73×10^4	3.74×10^4	-0.01×10^4	0.3%
Eutrophication- N	kg N	2.02×10^6	2.02×10^6	0	0
Global Warming Potential	kg CO_2 eq	5.95×10^7	5.95×10^7	0	0
Water Use	m^3 H_2O	2.06×10^7	2.07×10^7	-0.01×10^7	0.5%
Non- Renewable Energy	MJ Primary	1.23×10^9	1.36×10^9	**-0.13×10^9**	**10.5%**
Water Consumption	m^3 H_2O	3.24×10^5	2.83×10^5	**0.41×10^5**	**12.6%**

*Values in red indicate Bioaugmentation alternative is favorable
*Values in green indicate No Bioaugmentaion alternative is favorable
*Percentage differences greater than 10% in **BOLD**.

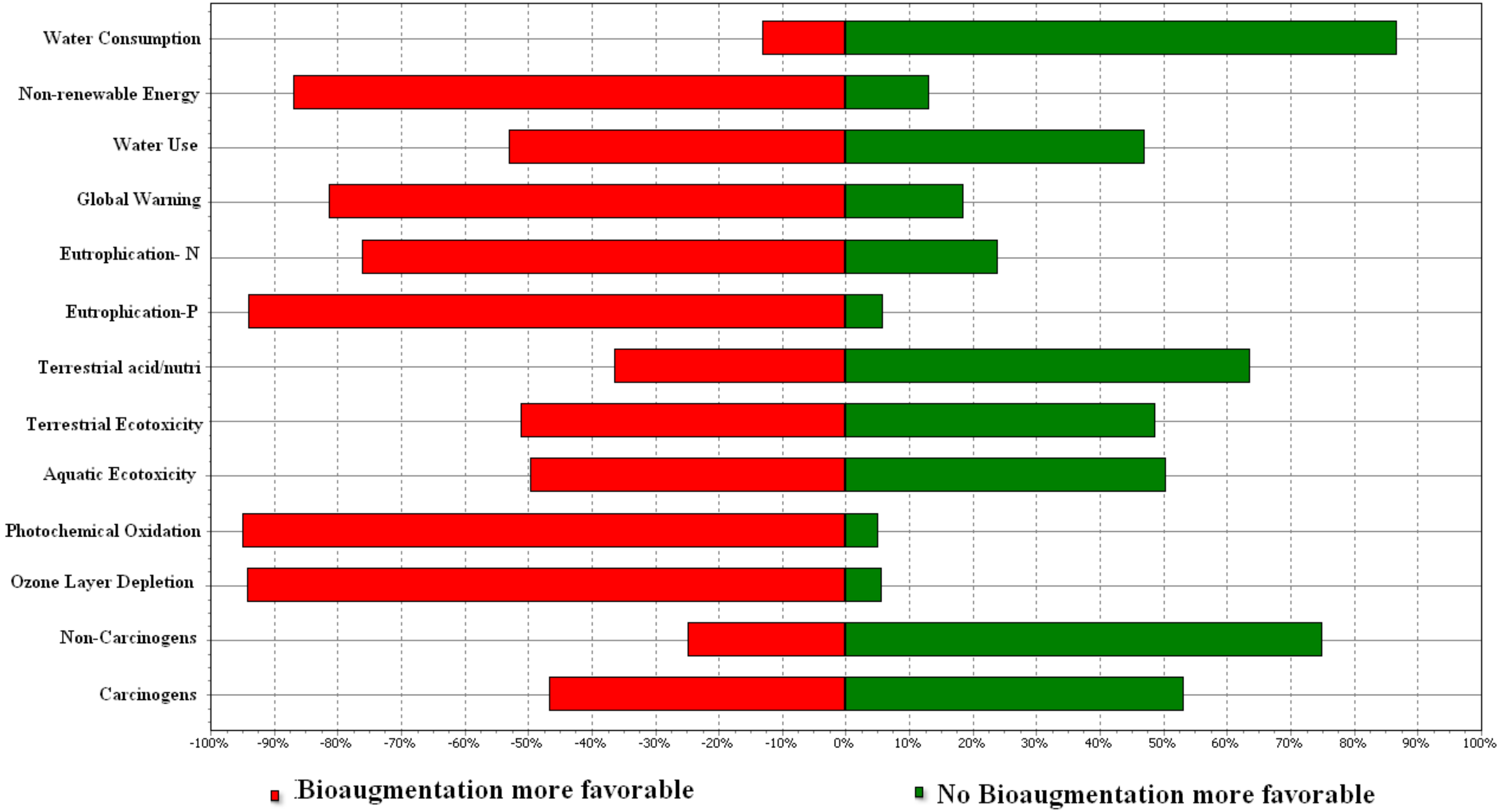
Monte-Carlo Analysis - GWP



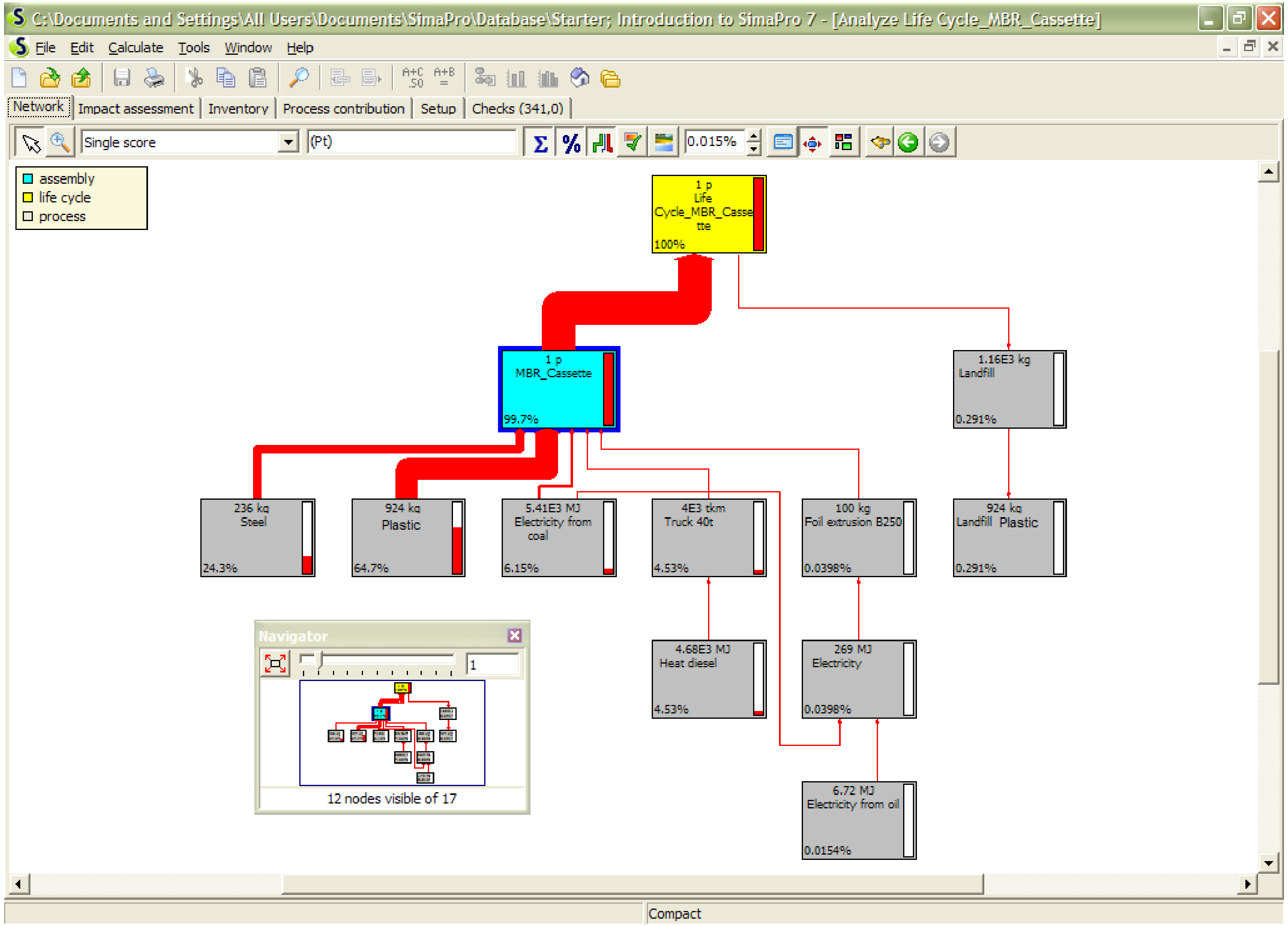
Comparative Monte Carlo Analysis - GWP



Comparative Monte Carlo Analysis – All Categories



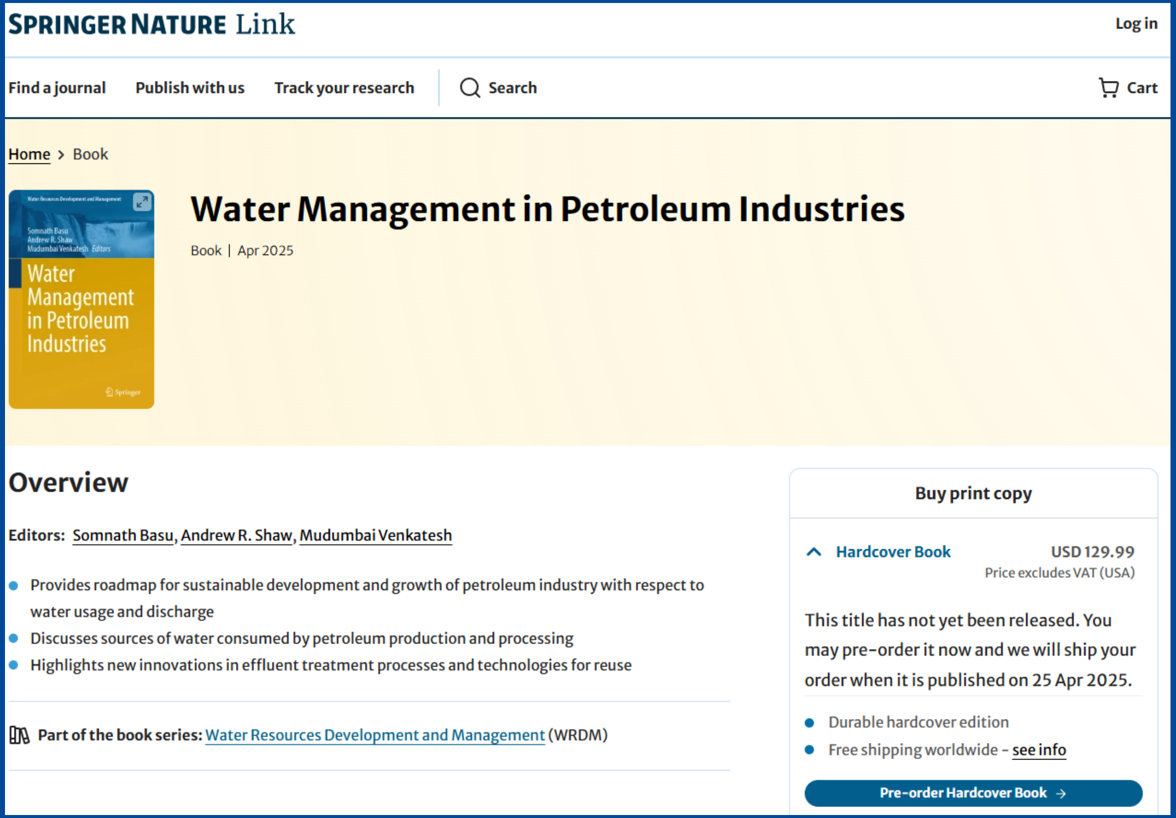
Example LCA Flow Diagram



Summary

- We have aging infrastructure
- Opportunity to build back better, and more sustainably
- Envision rating tool useful for assessing projects
- LCA useful for understanding a broad range of environmental Impacts

Shameless Plug…



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Water Management in Petroleum Industries

Book | Apr 2025

Overview

Editors: Somnath Basu, Andrew R. Shaw, Mudumbai Venkatesh

- Provides roadmap for sustainable development and growth of petroleum industry with respect to water usage and discharge
- Discusses sources of water consumed by petroleum production and processing
- Highlights new innovations in effluent treatment processes and technologies for reuse

Part of the book series: Water Resources Development and Management (WRDM)

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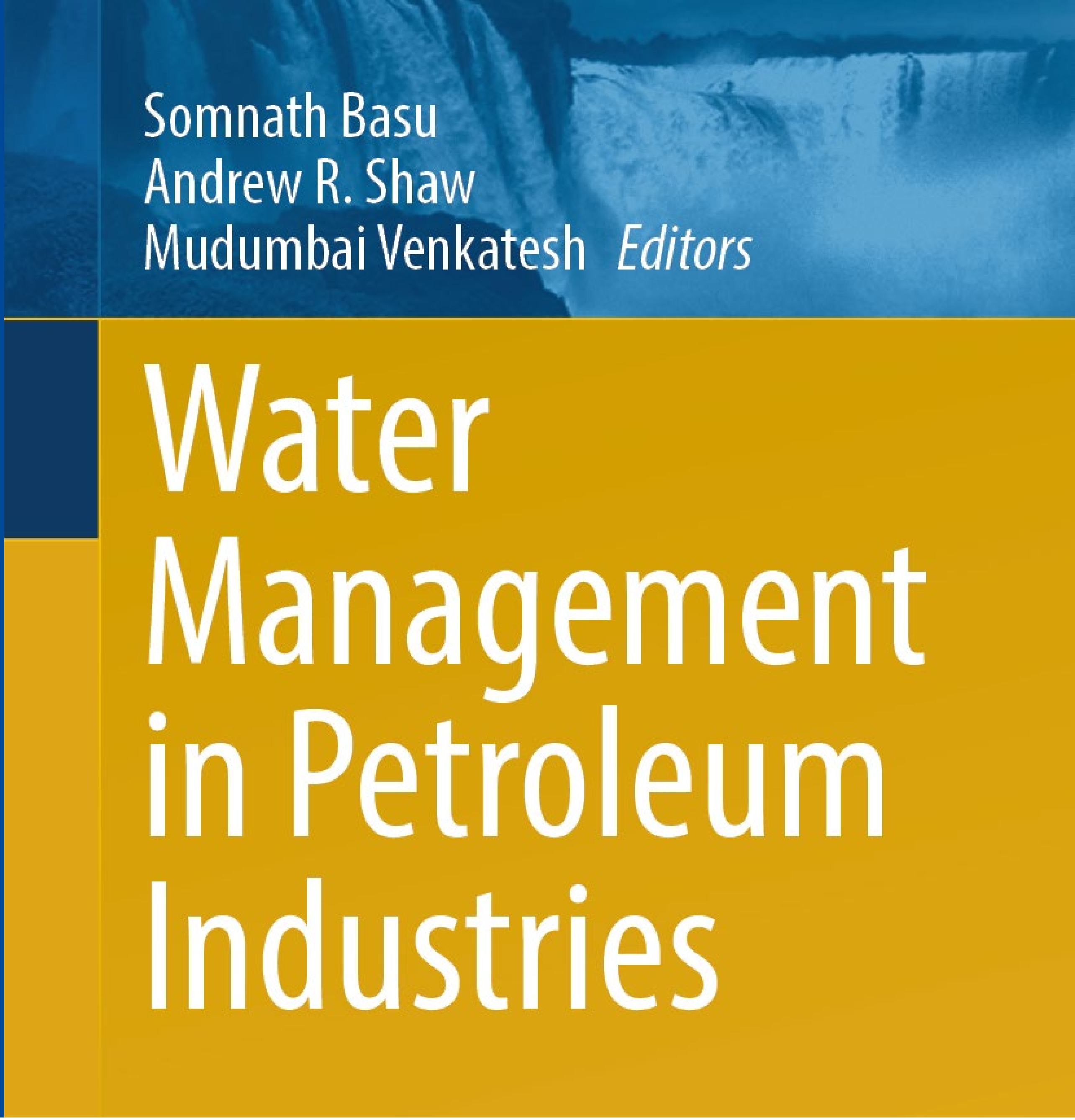

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