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American Water Works Association
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SUSTAINABLE Water Management Conference

Holistic Analysis of the Urban Water Systems in Greater Cincinnati Region

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Office of Research and Development
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Current Water Challenges Facing Urban Communities

- Water resource stress (quantity), safety (quality).
- Drinking water quality (pathogens, DBPs)
- Wastewater treatment (eutrophication)
- Combine sewer overflow (CSO)
- Storm water management (flooding)
- Aging infrastructure (rated as “D”)
- Financial burden ($540 billion gap in next 20 years)

“Siloed” water management approaches.

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A system is more than the sum of its parts.

– Aristotle (384-322 BC)

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Sustainable Urban Water Systems

System analyses comparing conventional and transformative community water systems and applications in community-based case studies

- Energy footprints and environmental impacts for current centralized water and wastewater systems - Greater Cincinnati region
  - Greater Cincinnati Water Works (GCWW)
  - The Metropolitan Sewer District of Greater Cincinnati (MSDGC)
  - Stormwater

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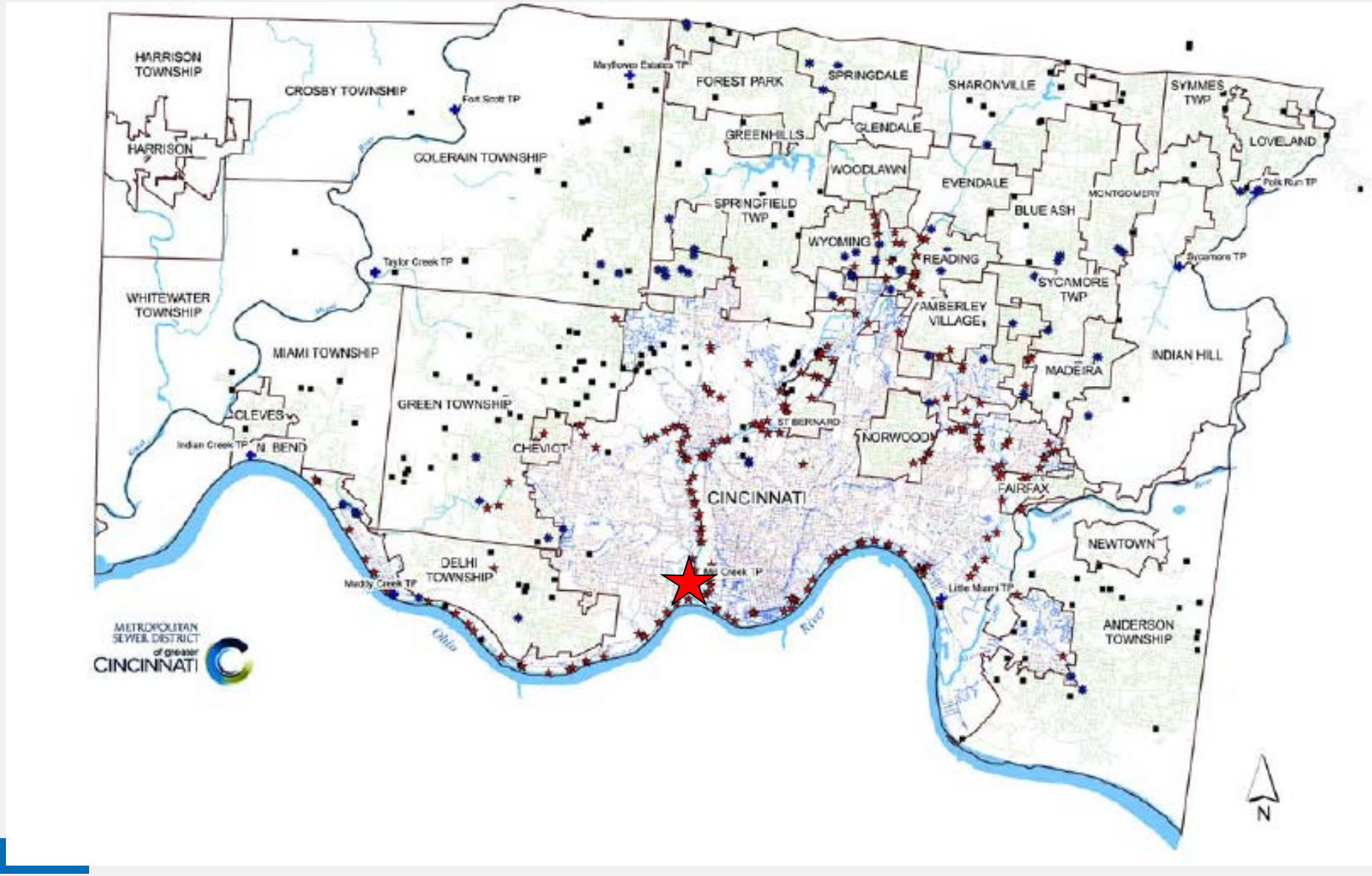
MSD Sewer System



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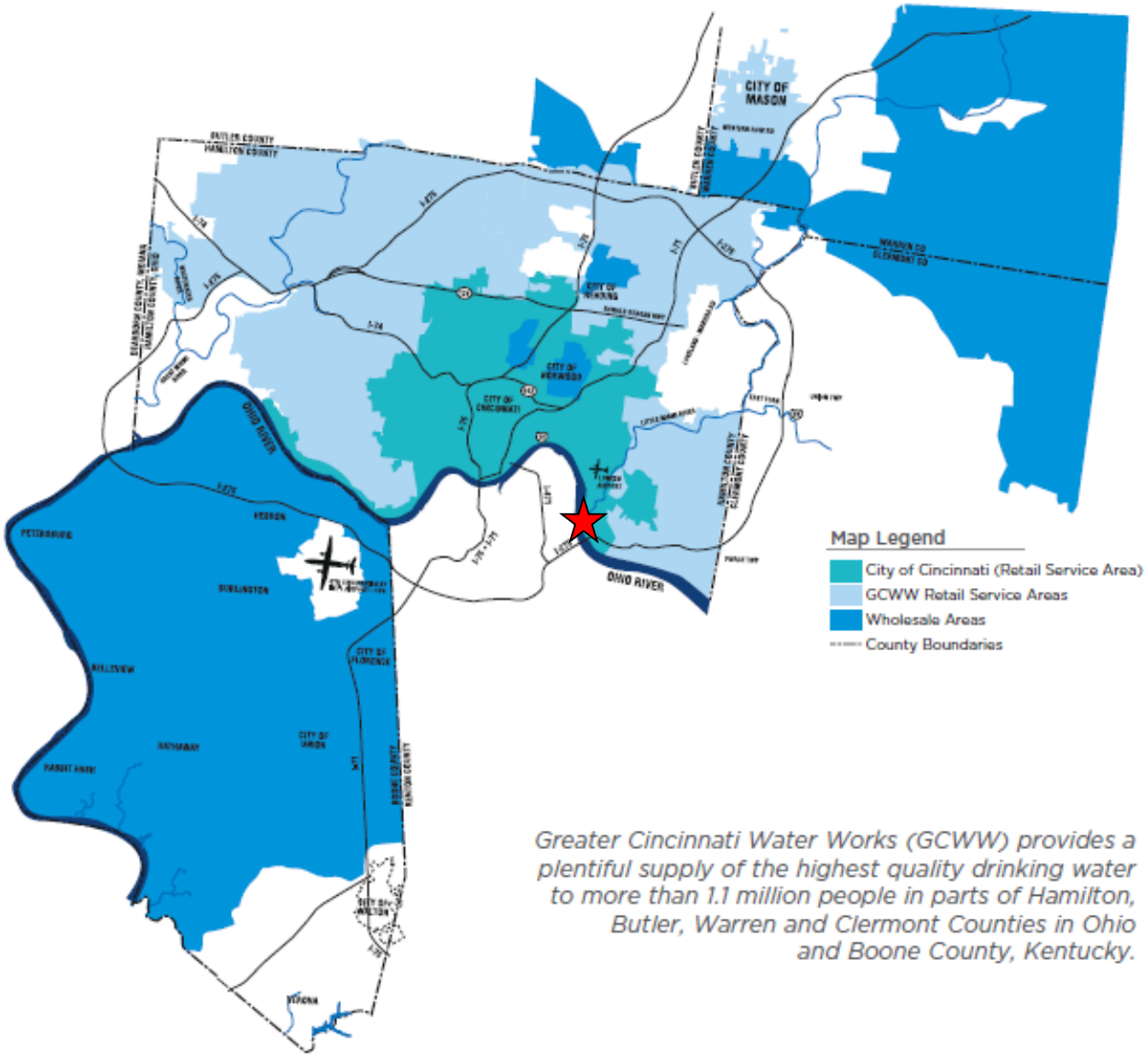
GCWW Service Area



Greater Cincinnati Water Works (GCWW) provides a plentiful supply of the highest quality drinking water to more than 1.1 million people in parts of Hamilton, Butler, Warren and Clermont Counties in Ohio and Boone County, Kentucky.

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DWTP and WWTP Parameters

Parameter	Unit	GCWW DWTP	MSDGC WWTI
Year of Inventory		2011	2011
Year Plant Built		1906	1959
Annual Volume Delivered/Discharged	MGD	89	114
Annual Volume Delivered/Discharged	m^3	123,560,247	157,615,342
Distribution/Collection Network Piping	mile	3,135	1,697
Distribution/Collection Network Piping	km	5,045	2,731
Geographic Area Served	km^2	--	344
Number of People Served	ppl.	830,000	518,000
Assumed Building, Tank and Pipe Lifetime	yr	100	100
Assumed Pump and Motor Lifetime	yr	25	25

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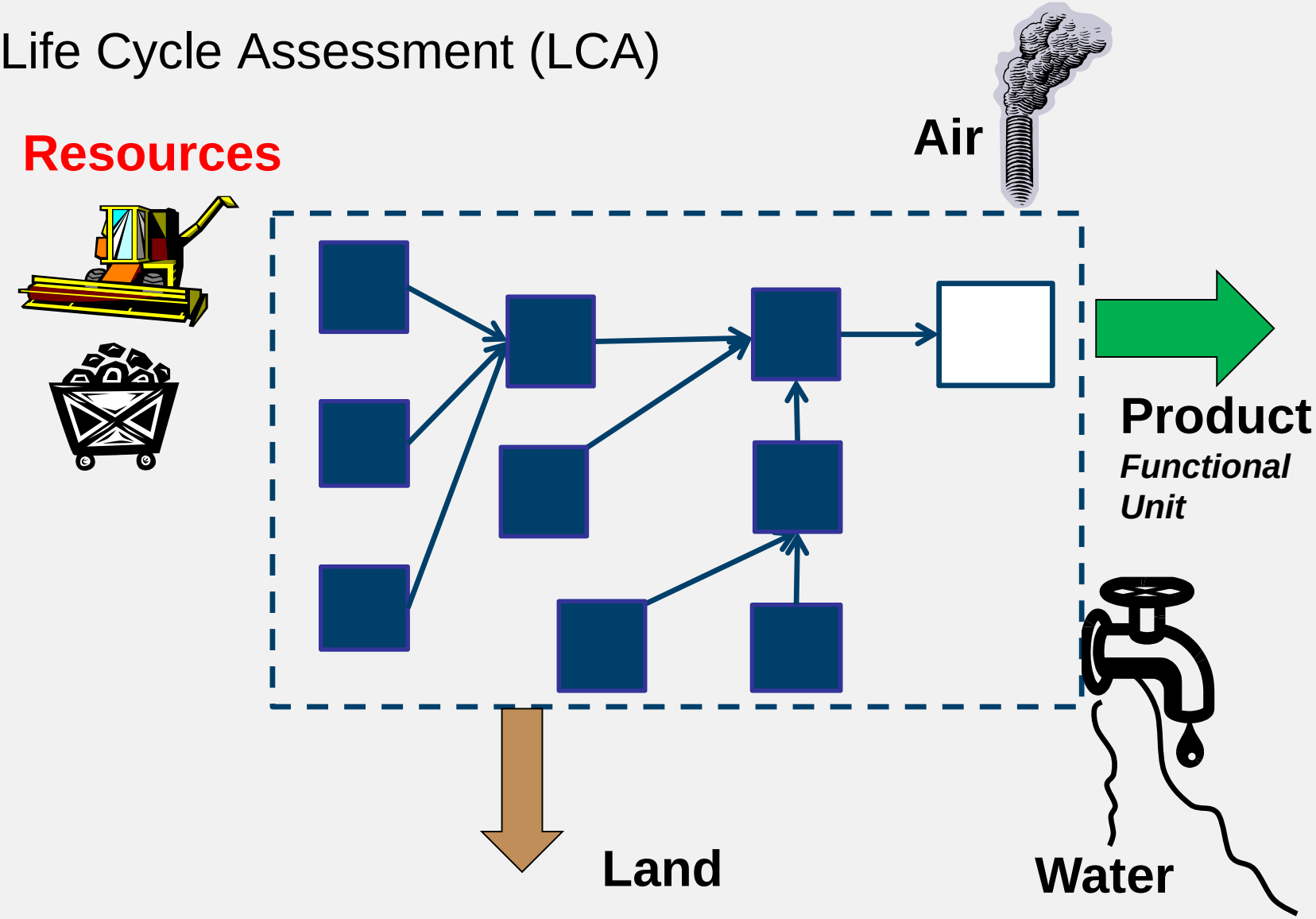
Sustainability Metrics

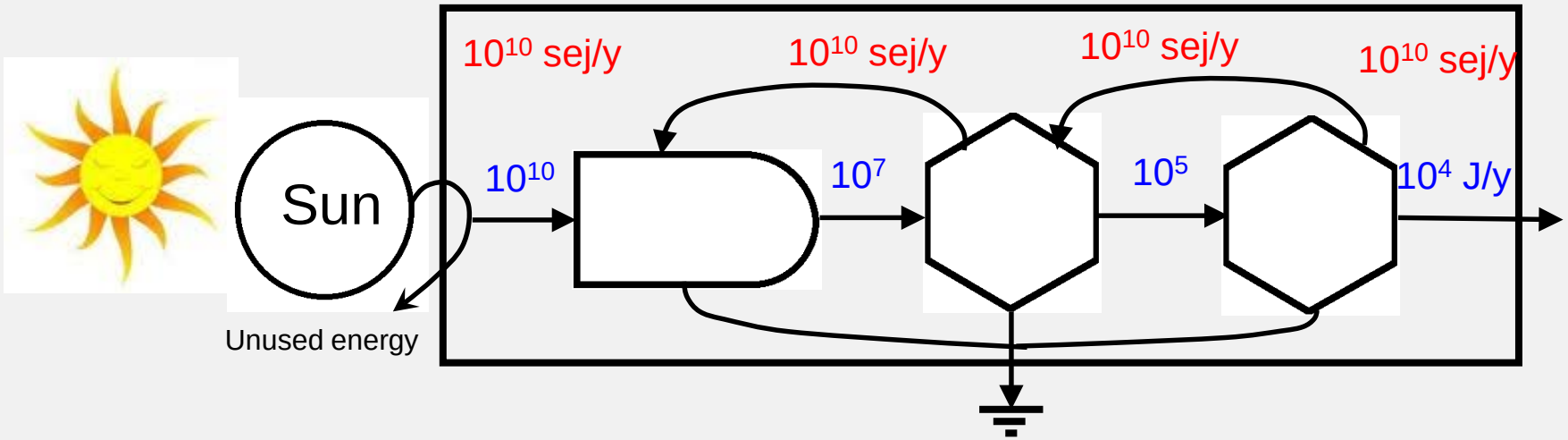
- Life Cycle Assessment (LCA)



Sustainability Metrics

- Emergy Accouting





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Life Cycle Assessment (LCA) and Life Cycle Cost (LCC) Analysis of the Water Systems in Greater Cincinnati Region

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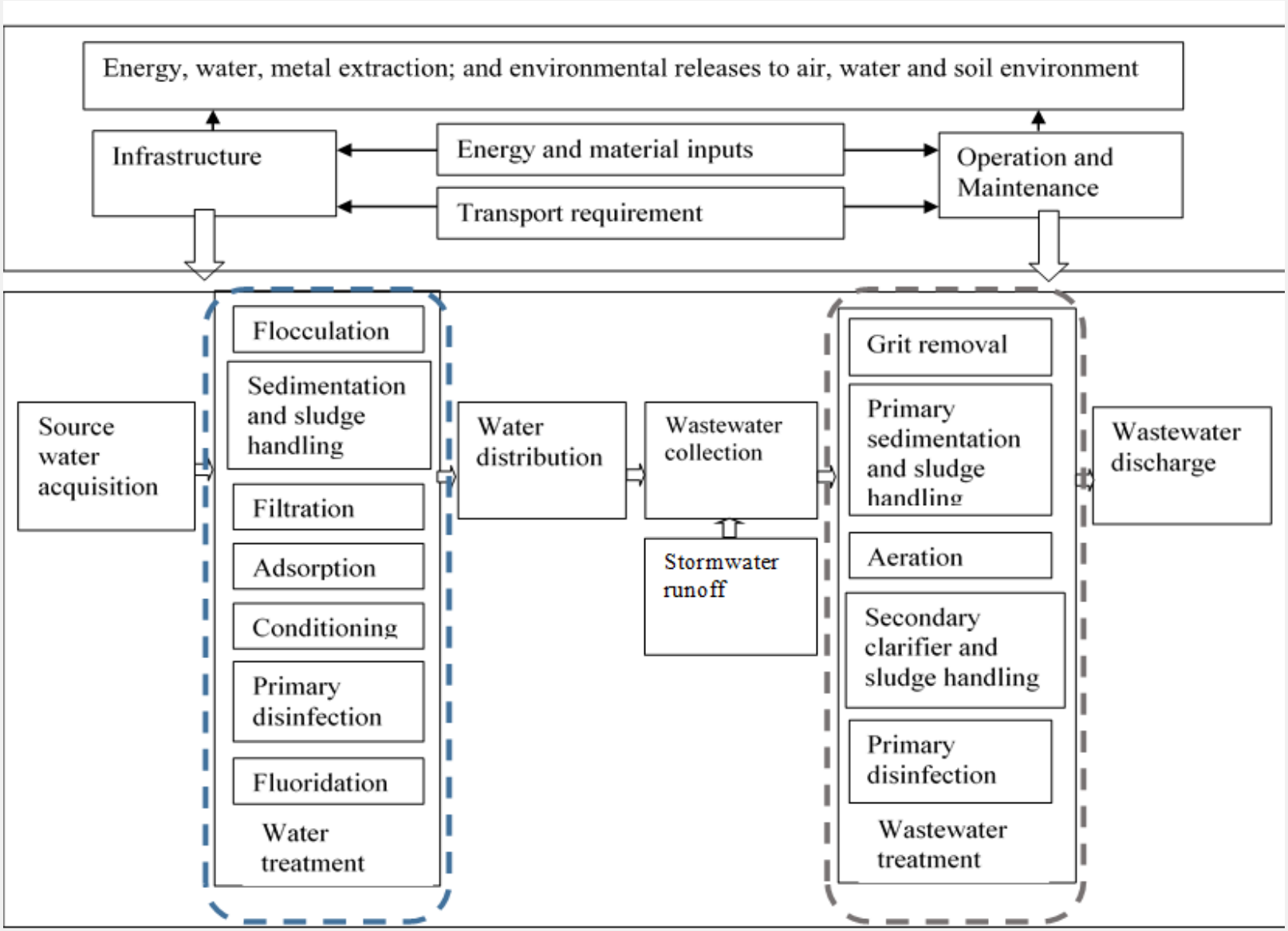
Life Cycle of Water and Wastewater Systems in Greater Cincinnati



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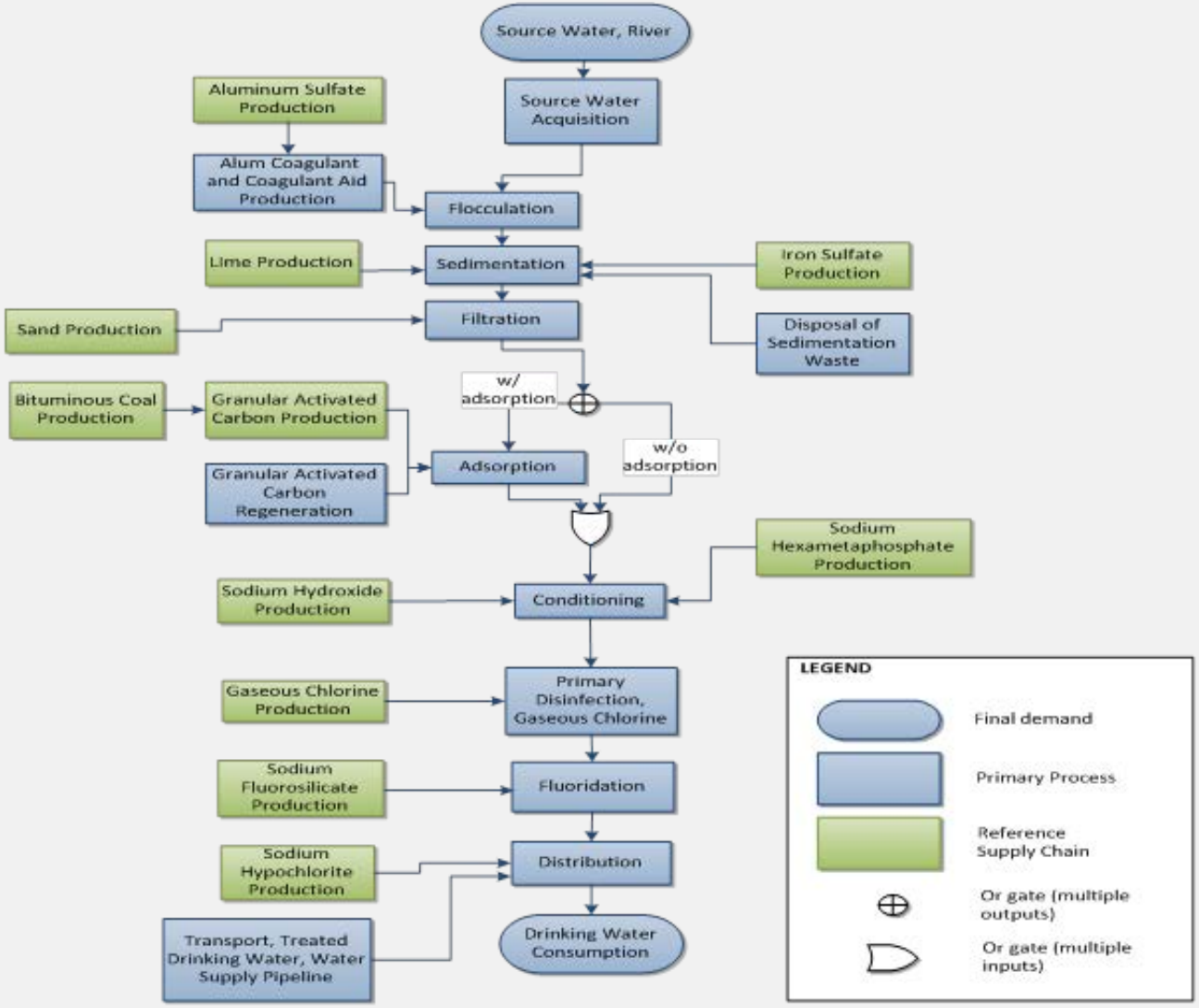
System Boundary of Cincinnati Water Treatment Base Case Model



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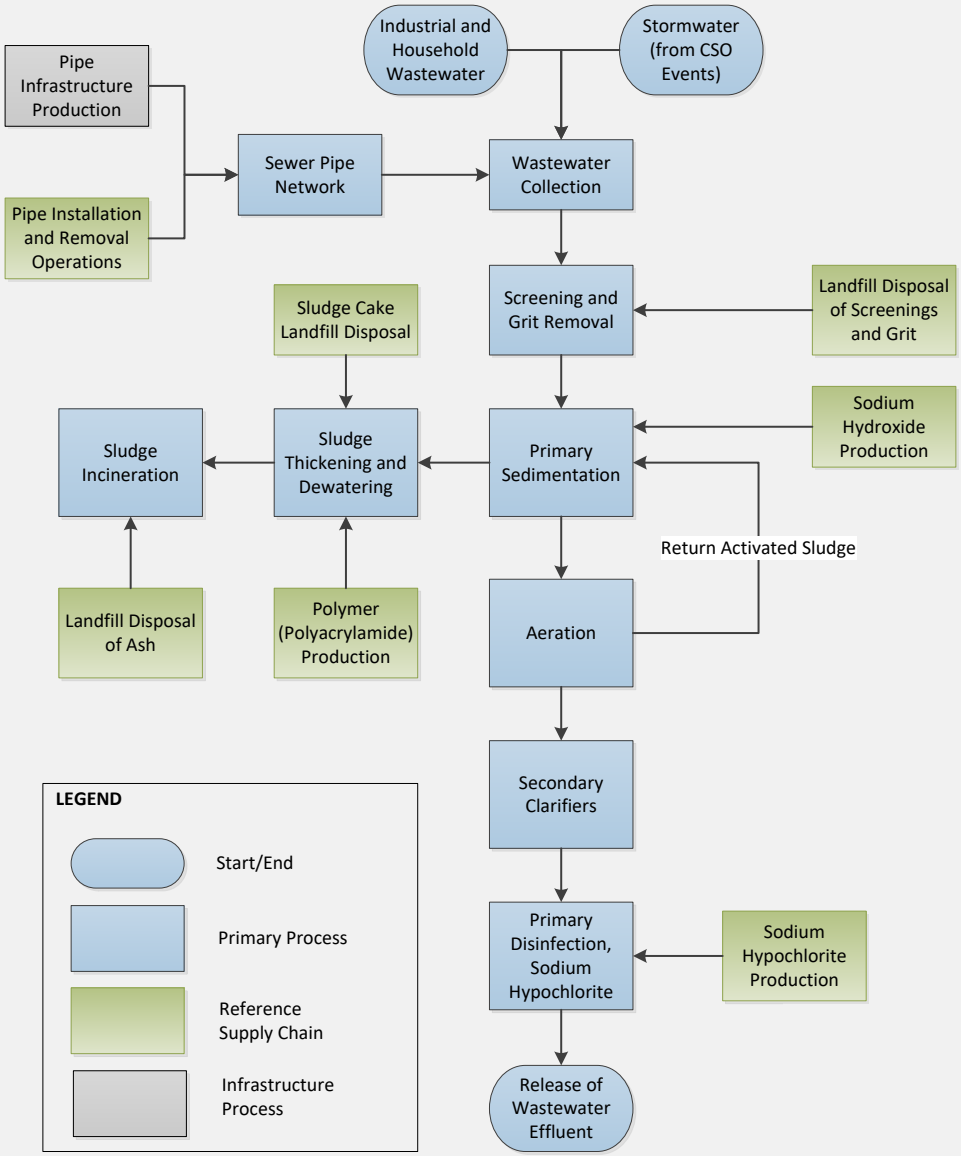
System Boundary of Cincinnati Wastewater Treatment Base Case

- System boundary starts at collection of wastewater in primarily a gravity sewer system
- The plant modeled uses activated sludge treatment and does not address nutrient removal
- Sludge at the plant is incinerated in fluidized bed reactors



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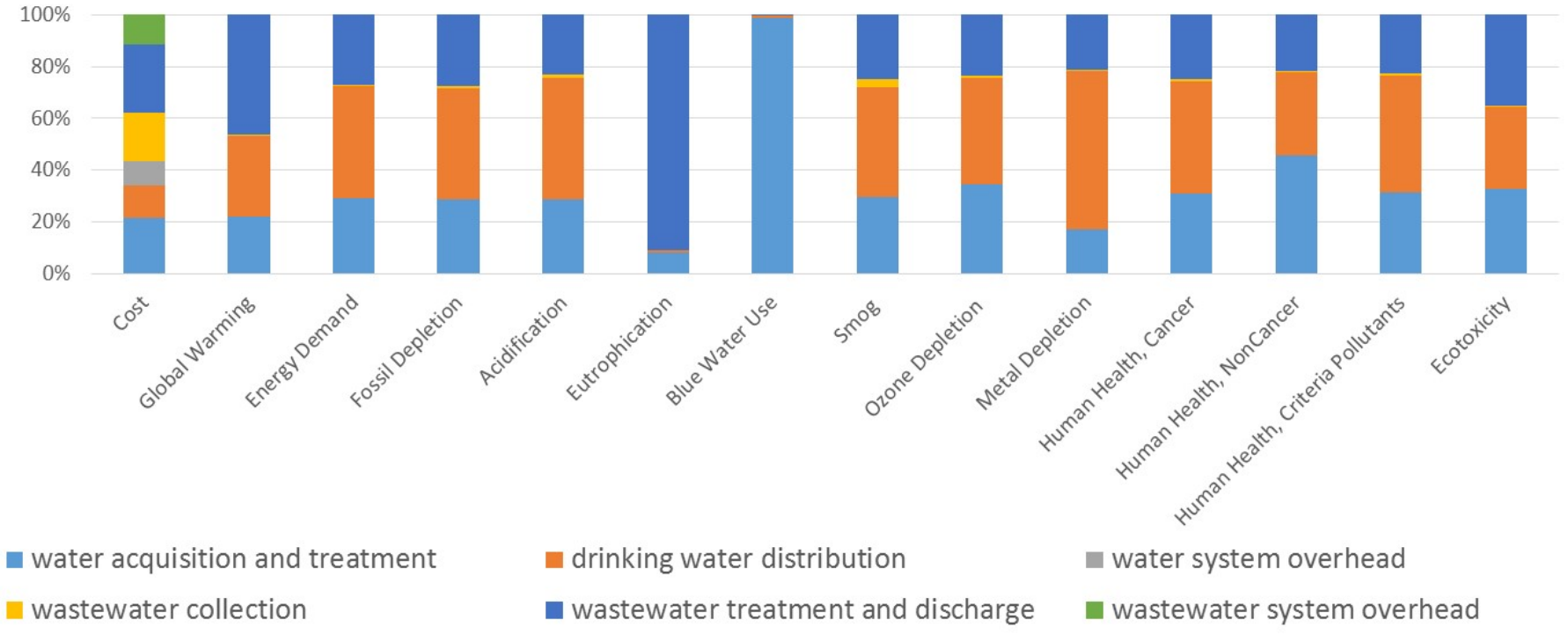
Contributions of Treatment Processes on Life Cycle Impacts of Water and Wastewater Systems in Cincinnati



Note: the overhead is only considered as a stage for cost. Cost analysis includes the costs during operation and maintenance stage.

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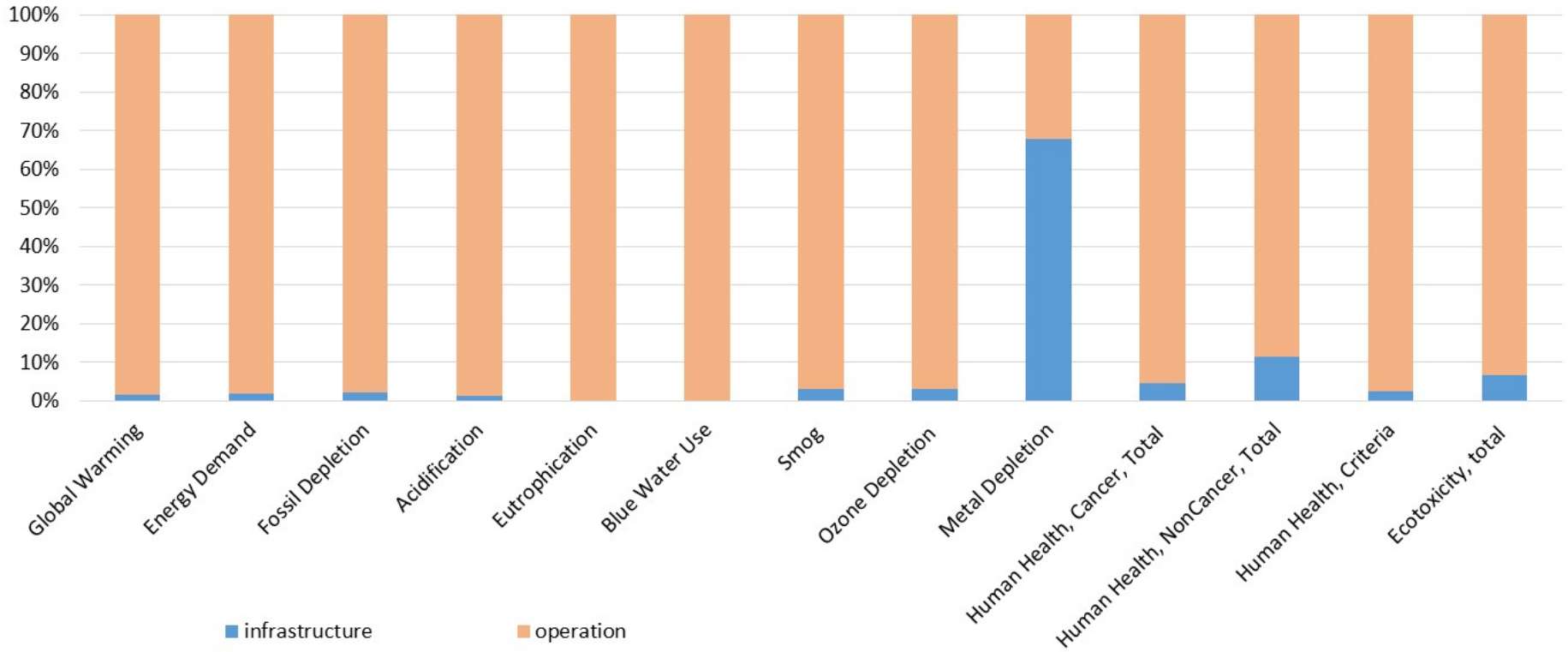
Contributions of Infrastructure and Operation Stages on Life Cycle Impacts of Water and Wastewater Systems in Cincinnati



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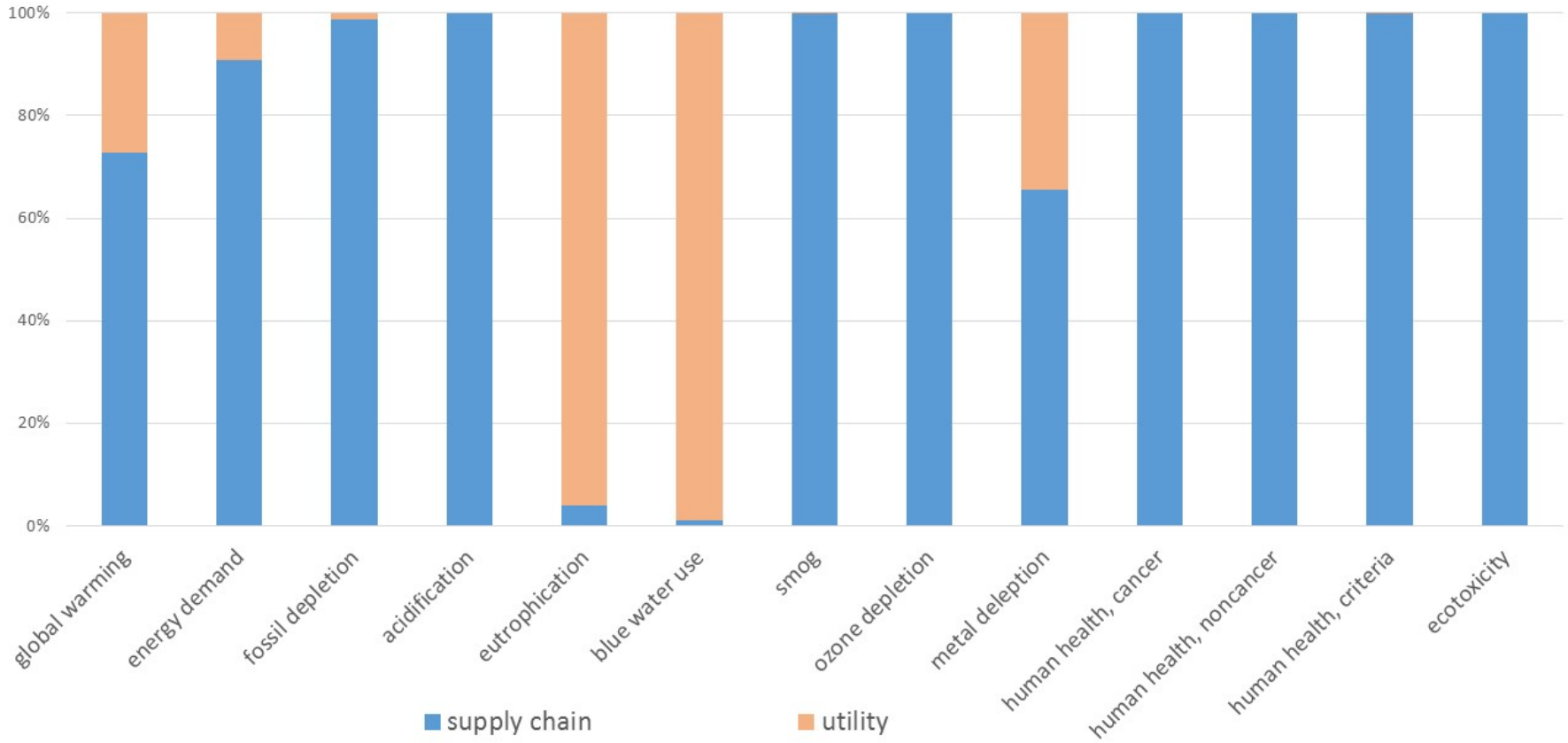
Contributions of Supply chain and Local Activities of Water and Wastewater Systems for Various Impact Categories



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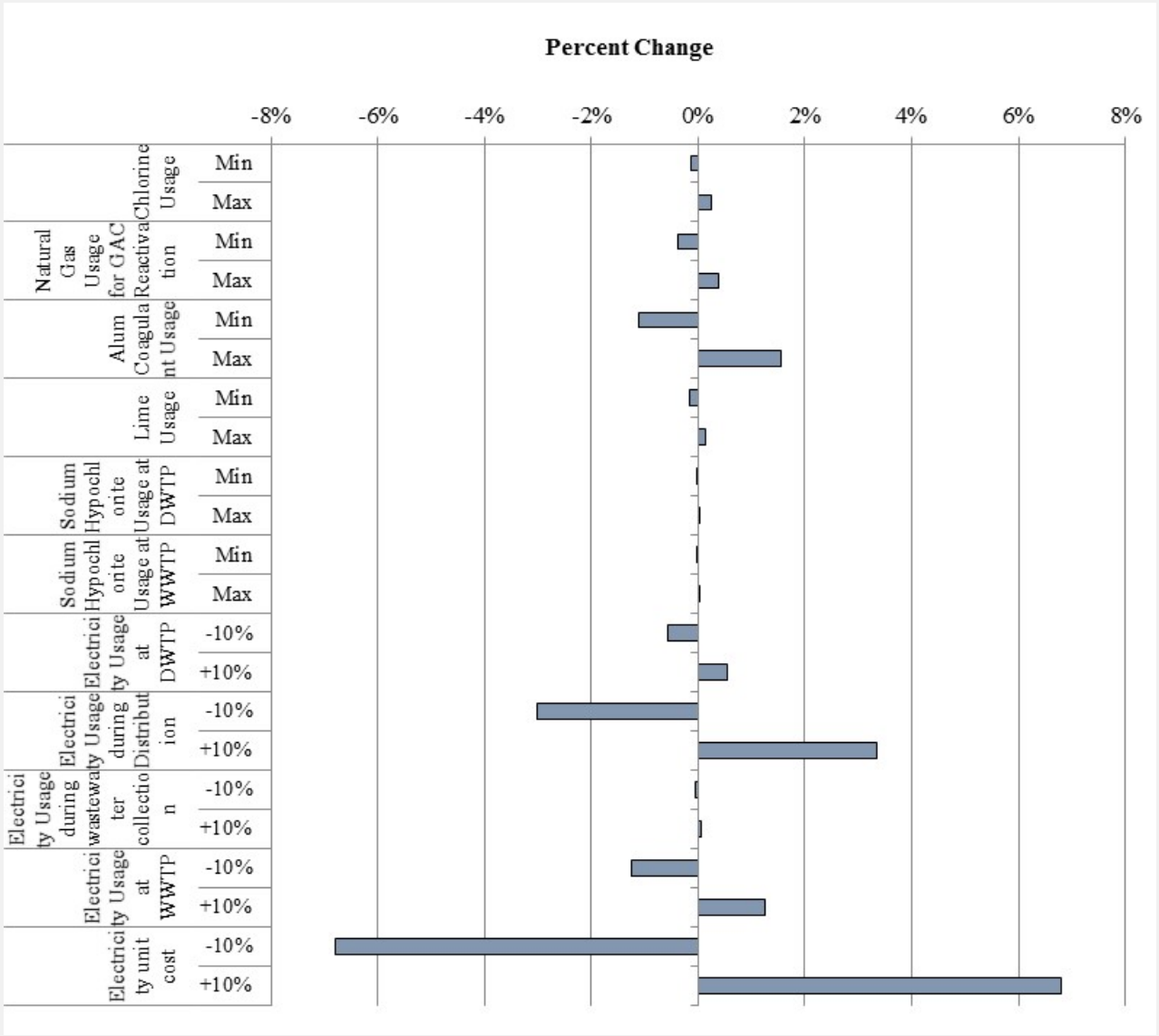
Sensitivity of Costs to Various factors



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Take Home Messages

- Electricity use is a key contributor to environmental impact, indicating the potential benefit of investing in energy efficiency.
- Operation contributes overwhelmingly high impacts across all categories except metal depletion for the initial piping materials
- The cost of water and wastewater systems was sensitive to electricity unit cost and consumption

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An Emergy Accounting Approach: Resource Use of an Urban Water System in Greater Cincinnati Region

EMERGY Units

- Material (per mass) – specific emergy

$$\frac{\text{total emergy input}}{\text{mass output}} = \text{sej/g}$$

- Energy (per joule) –Transformity

$$\frac{\text{total emergy input}}{\text{energy output}} = \text{sej/J}$$

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Emergy Analysis Results

	GCWW DWTP		MSDGC WWTP	
Annual Inputs	sej/yr	sej/m³	sej/yr	sej/m³
Plant Inputs	9.2E+19	7.5E+11	9.7E+19	6.1E+11
Plant Infrastructure	1.1E+19	8.5E+10	1.8E+19	1.2E+11
Distribution/Collection Inputs	6.0E+19	4.9E+11	1.3E+19	8.2E+10
Distribution/Collection Infrastructure	4.9E+19	4.0E+11	1.6E+19	1.0E+11
Total without Distribution/Collection	1.0E+20	8.3E+11	1.2E+20	7.3E+11
Total with Distribution/Collection	2.1E+20	1.7E+12	1.4E+20	9.1E+11

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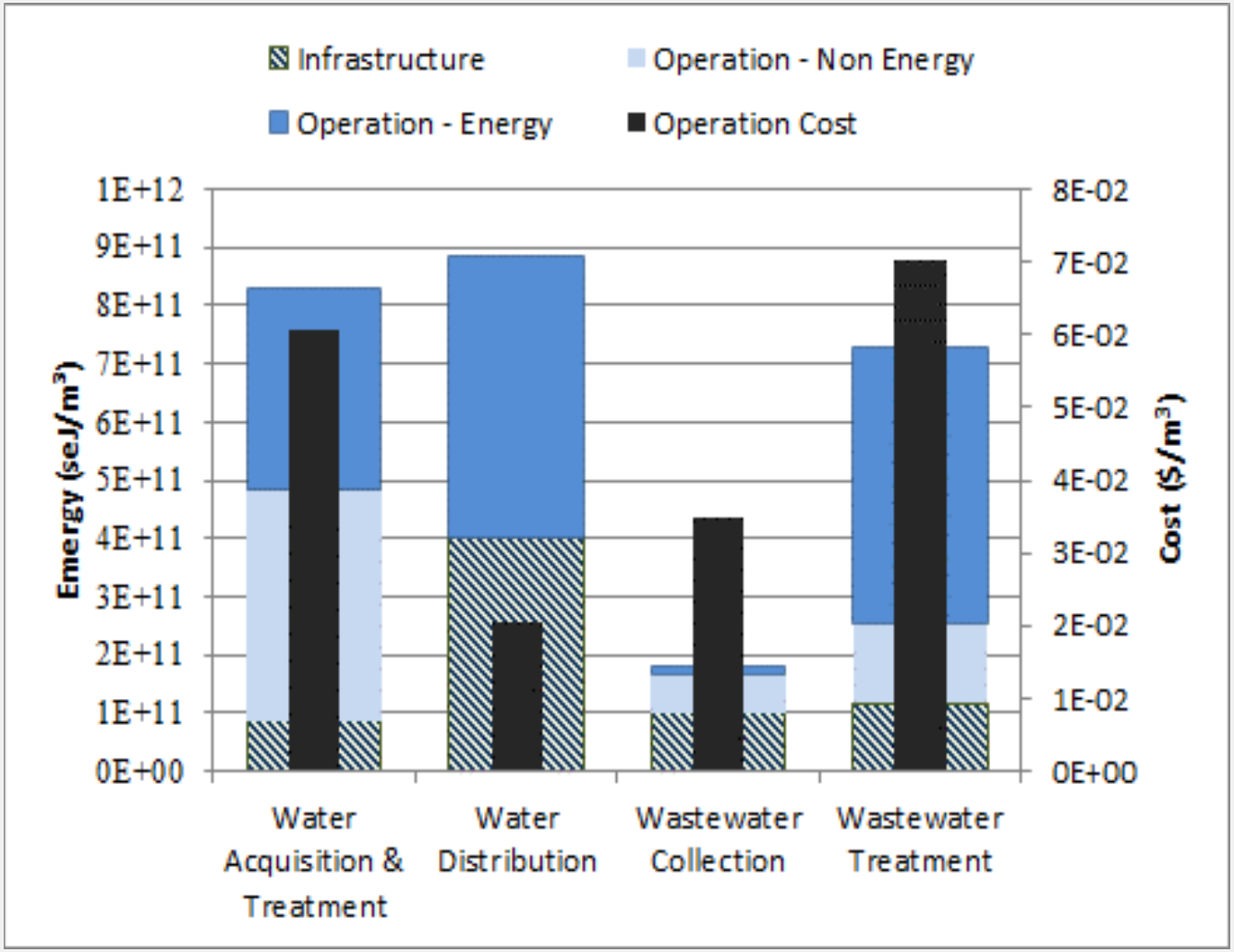
Infrastructure Emergy, Operation Emergy and Operation Cost by Major Treatment Stages



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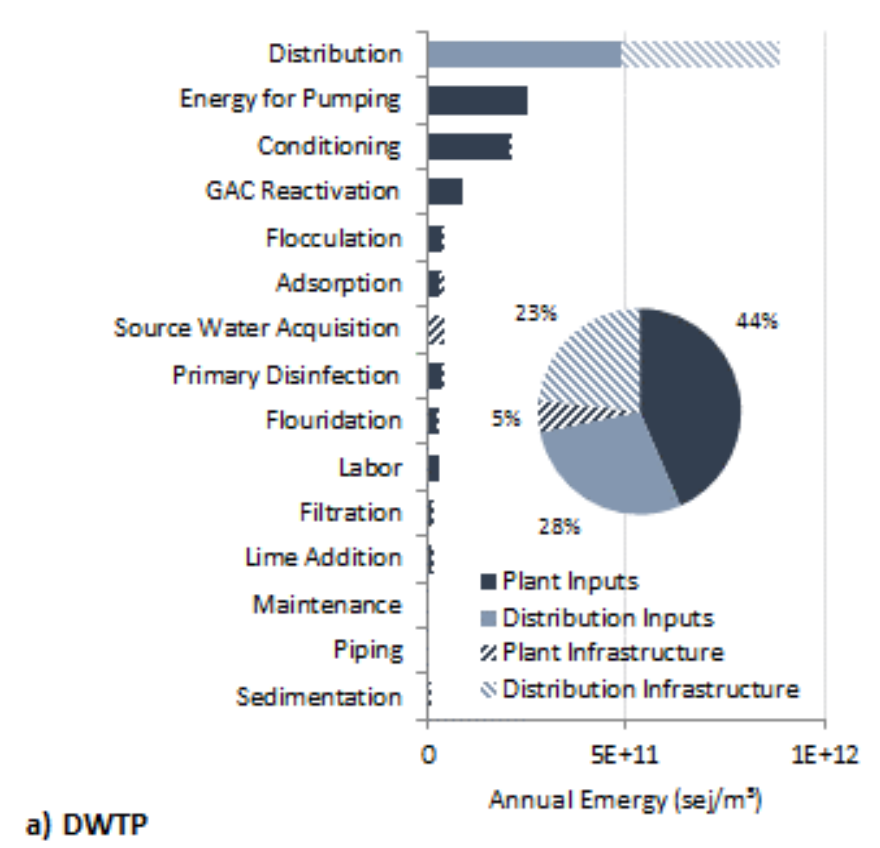
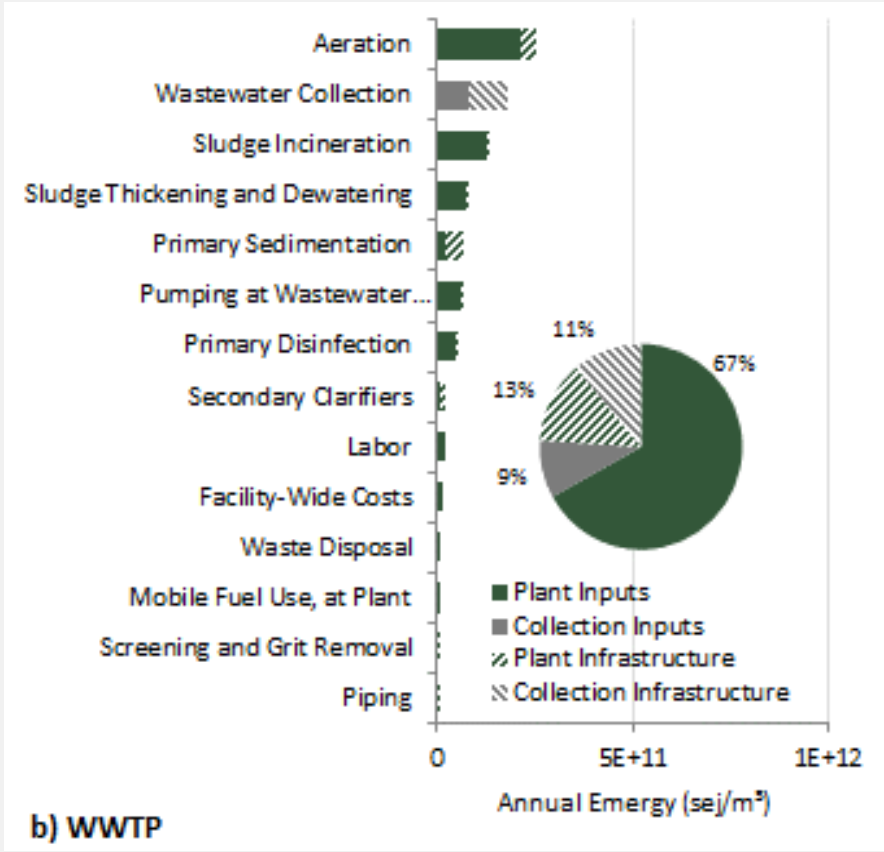
Annual and Infrastructure Emergy inputs





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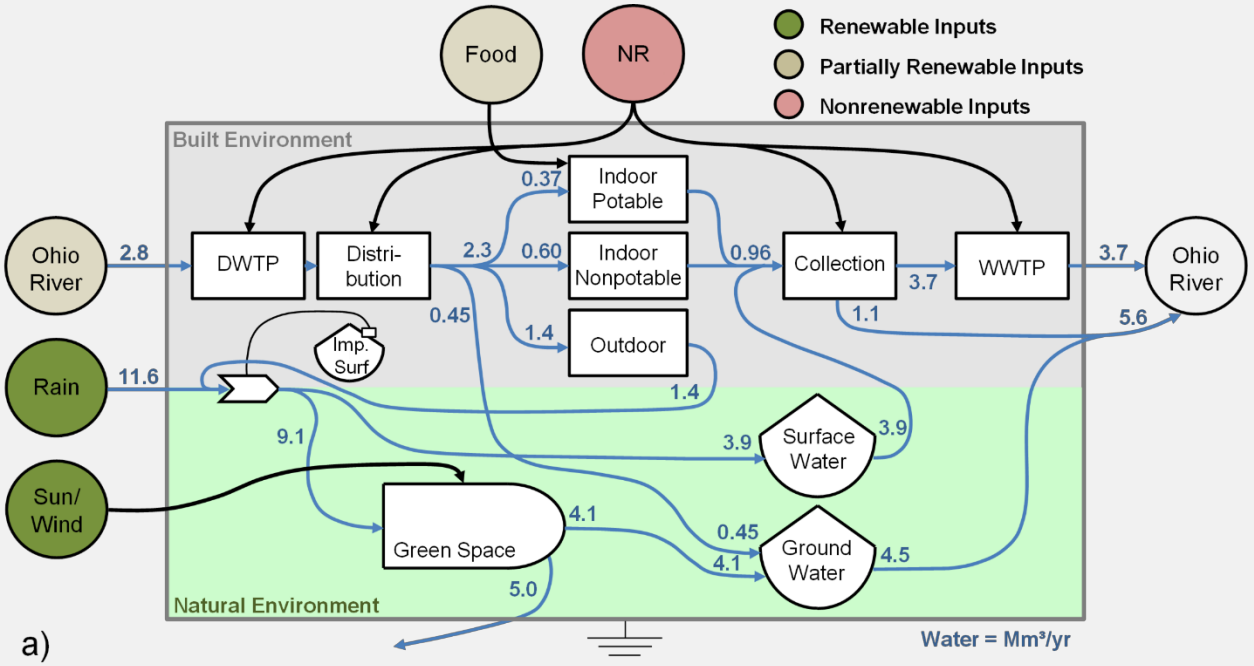

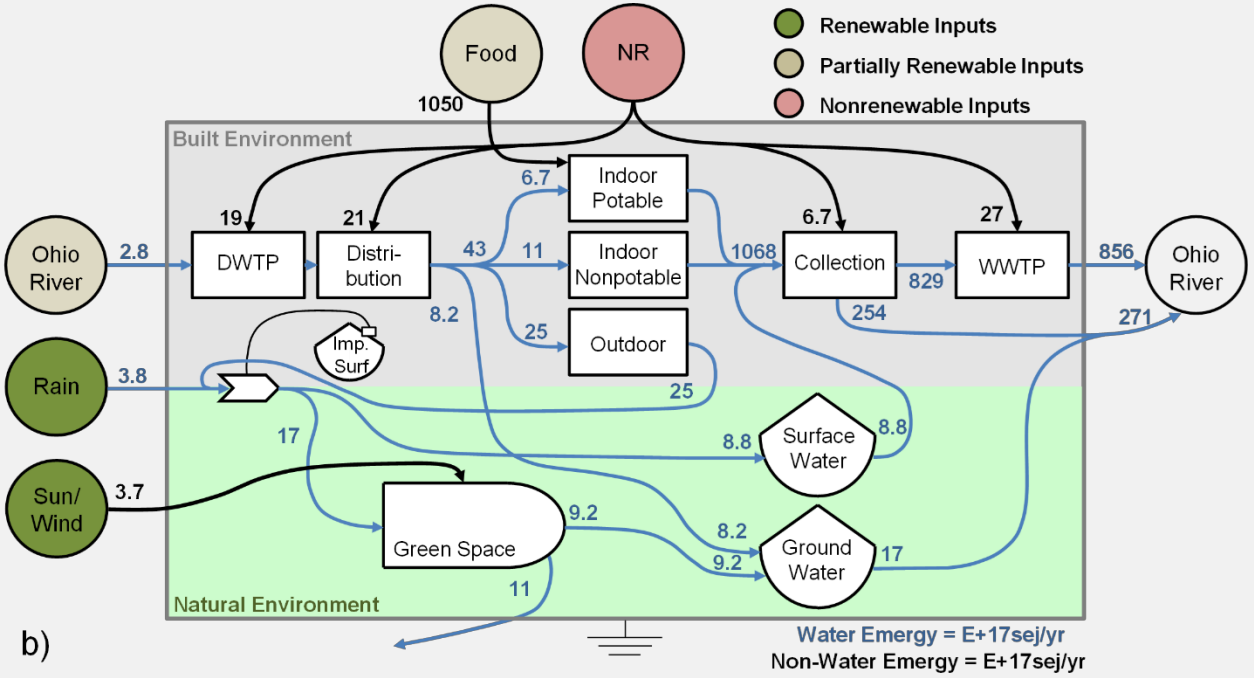

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Take Home Messages

- Whole system thinking to deal with a suite of urban water issues
- Holistic thinking to achieve global system efficiency (Sustainability)
- New concepts
  - Fit for purpose
  - Source separation and resource recovery
    - Nutrient recovery
    - Energy recovery
  - Decentralization
  - Water-Energy-Nutrient-Food nexus

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