Wastewater Treatment Energy Recovery Potential

An Integrated Assessment

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Western Engineering

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Introduction

- Anthropogenic nutrient impact on SW quality
- Rapidly increasing population and urbanization
- Harmful algae blooms and fish kills
- SDGs propose 50% reduction in untreated wastewaters

Introduction

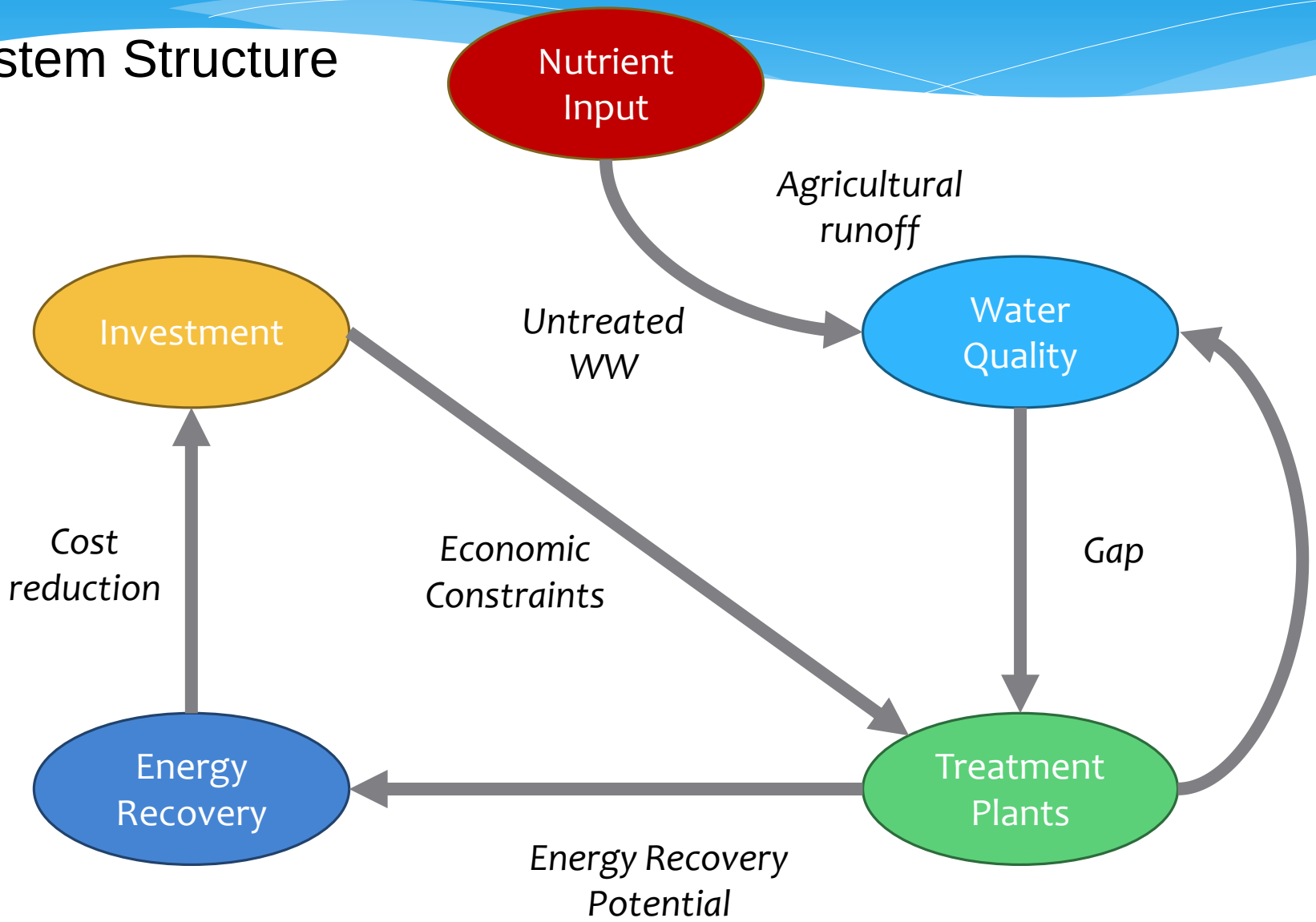
- Economic barriers for plant construction and upgrade
- Chemical energy recovery from wastewater treatment processes can be utilized to offset
  - Biogas utilization
  - Biosolids incineration

Introduction

- **Questions:**
  - How will treated wastewater fractions have to change to avoid surface water degradation?
  - Can energy recovery help to offset the cost of treatment so that more plants can be constructed?
- **Objective:**
  - Create a hypothetical dynamic scenario to evaluate feedbacks between wastewater treatment, energy recovery, and water quality

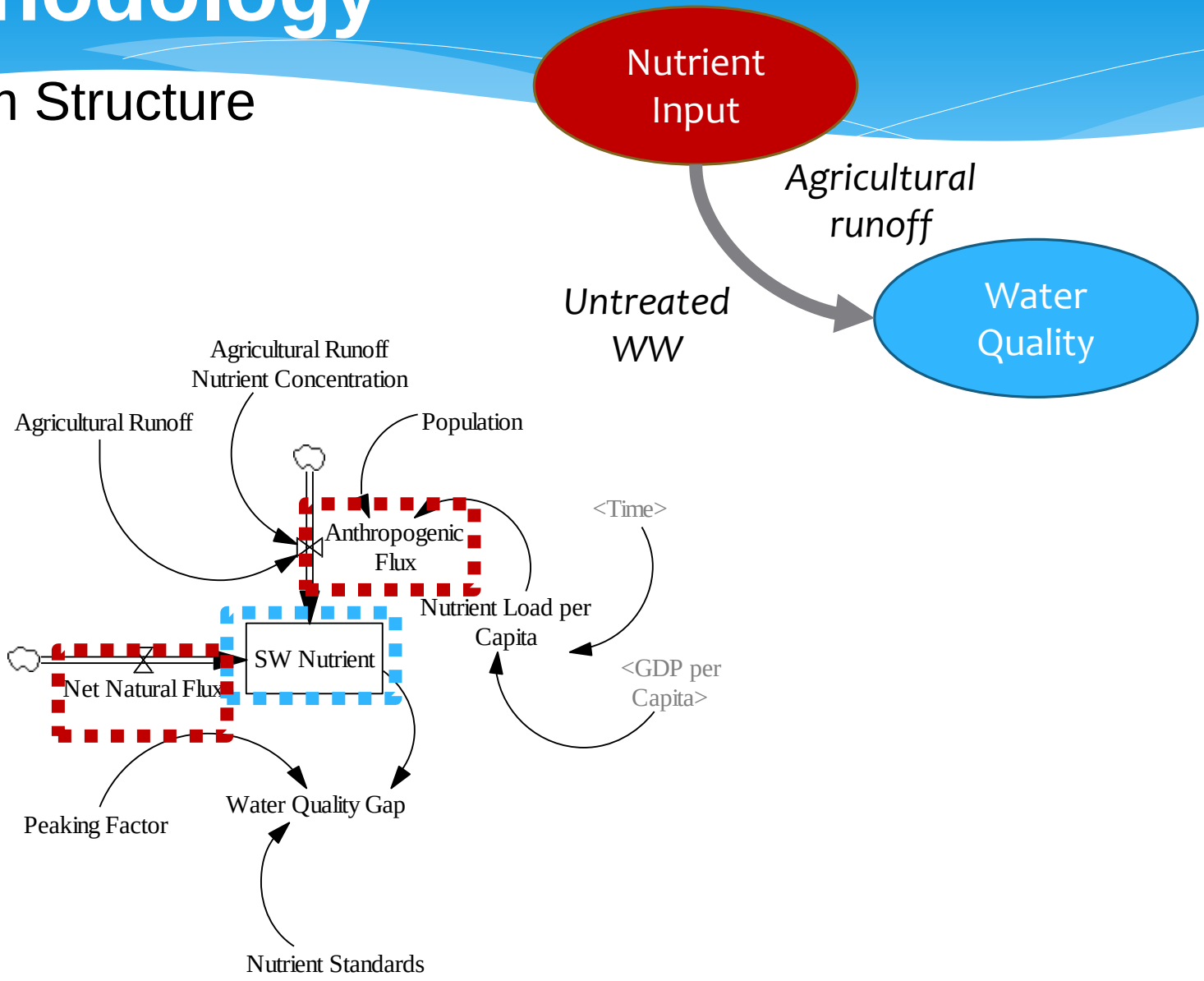
Methodology

System Structure



Methodology

System Structure



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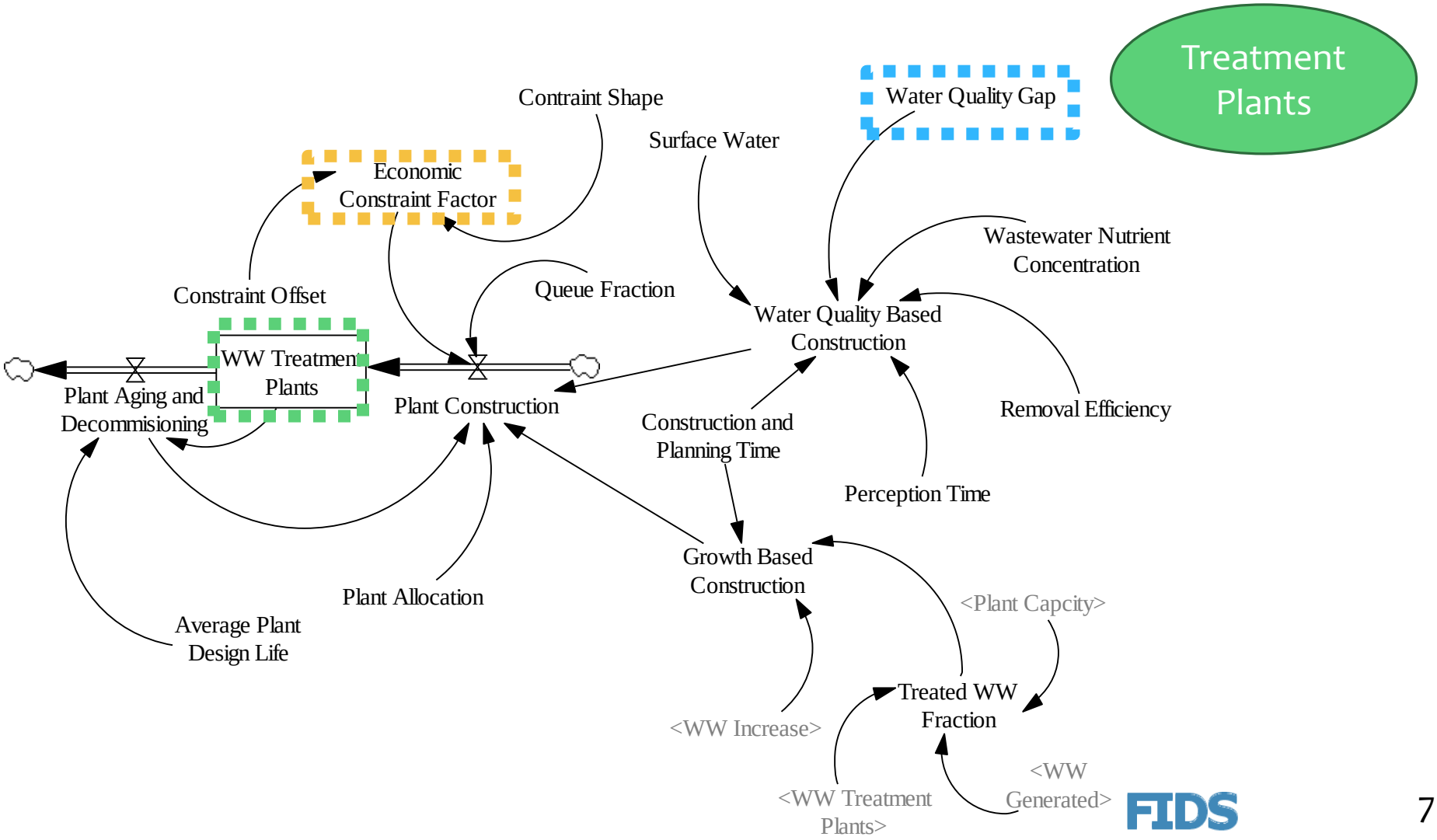

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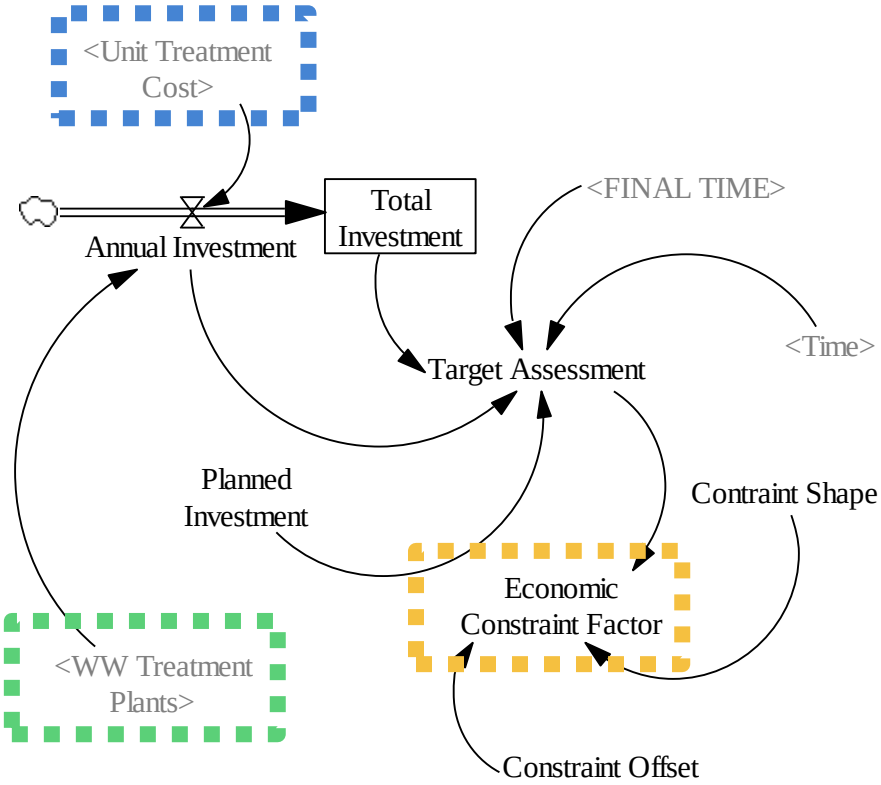
Methodology

System Structure

Investment



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Methodology

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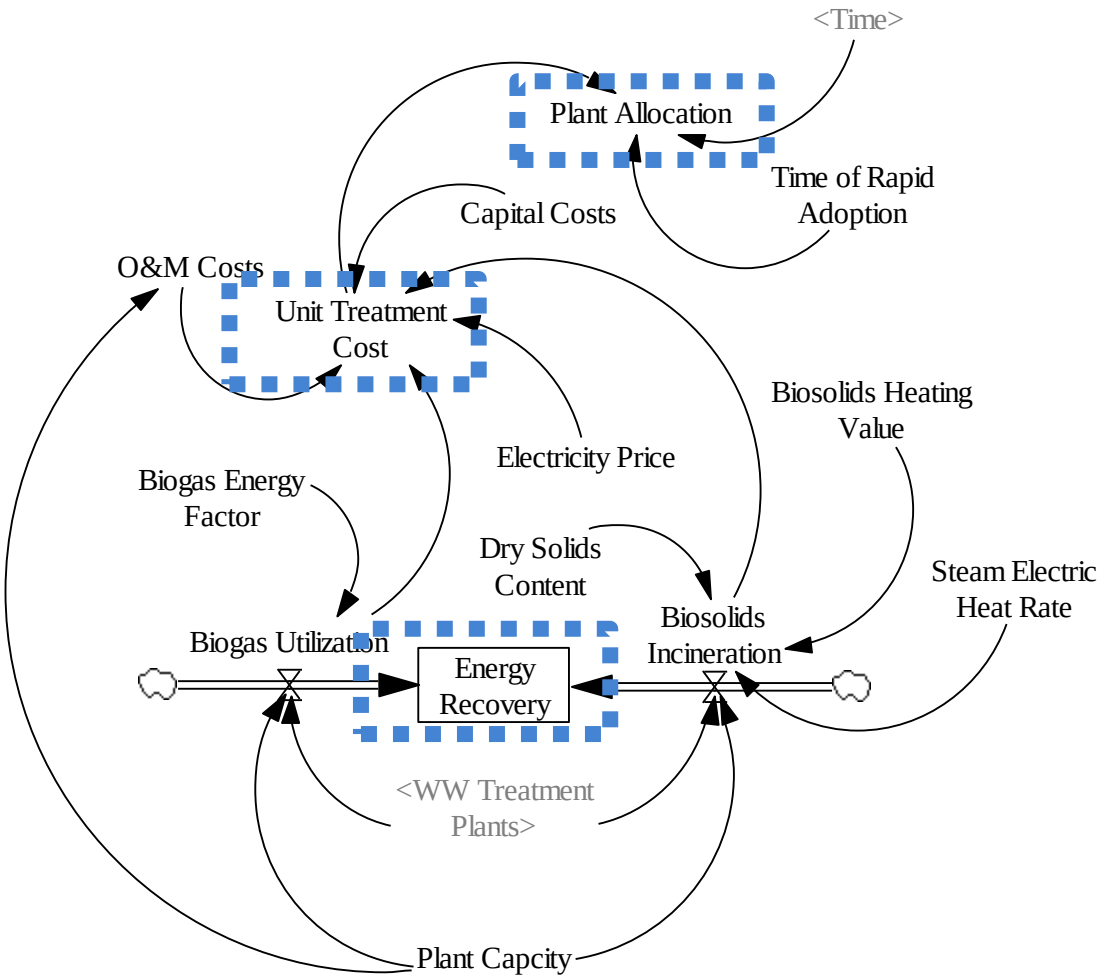


Energy Recovery

$$Biogas\ Energy\ Recovery = BEF * Q$$

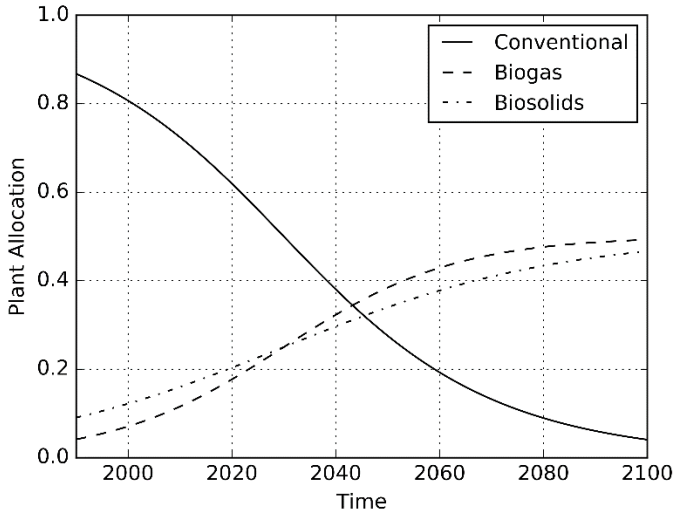
$$Biosolids\ Energy\ Recovery = \frac{Q * C_s * HV}{HR}$$

Methodology

Assumptions

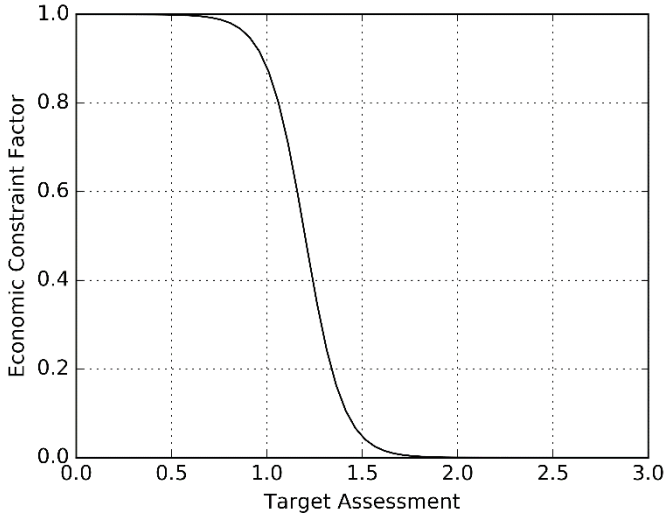
Future Plant Allocation

$$Plant\ Allocation_i = 0.5 * \left(1 + \exp\left(-\frac{t - T_i}{P_i * R_i}\right)\right)^{-1}$$



Economic Constraints

$$Target\ Assessment = \frac{Total\ Investment + Annual\ Investment * \left(t_f - t\right)}{Planned\ Investment}$$



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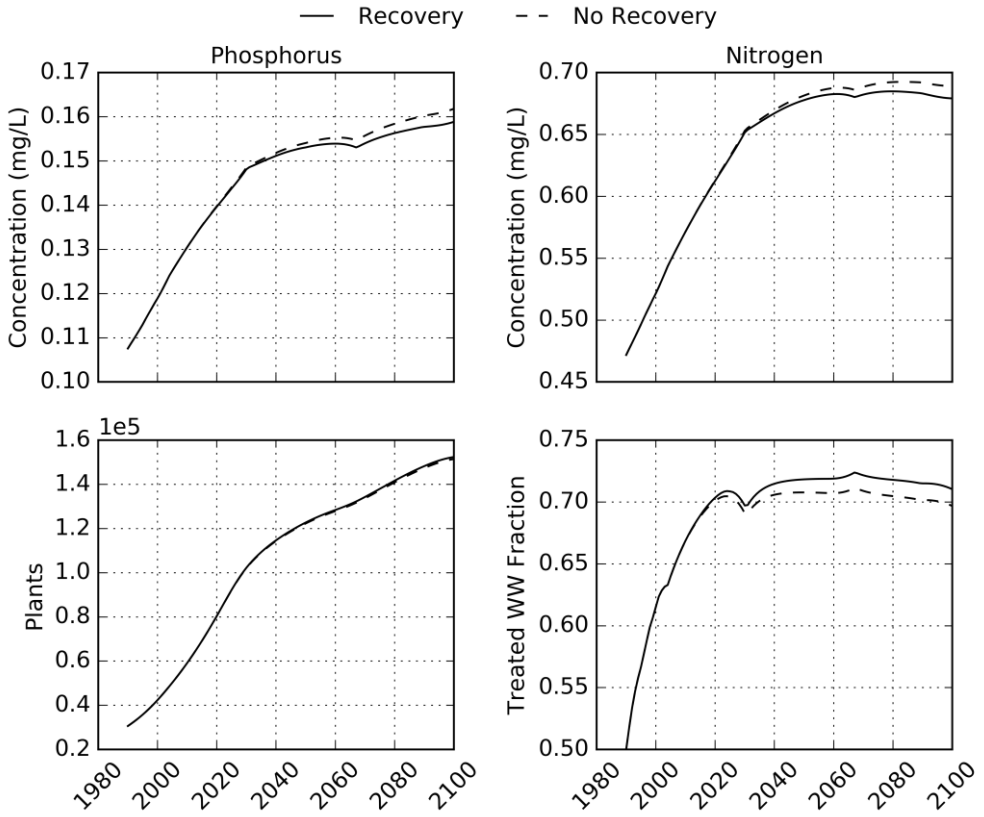
Methodology

Parameterization – Monte Carlo Analysis

Parameter	Unit	Min.	Peak	Max.
Constraint Shape	-	0.8	0.1	0.3
Time of Rapid Adoption	years	2025	2030	2060
Queue Fraction	-	0.01	0.05	0.1
Perception Time	years	5	15	25
Construction + Planning Time	years	5	10	15
Plant Capacity	m^3/day	5000	11130	30000
Planned Investment	billion $	250	500	750
Peaking Factor	-	4	5	6

Results

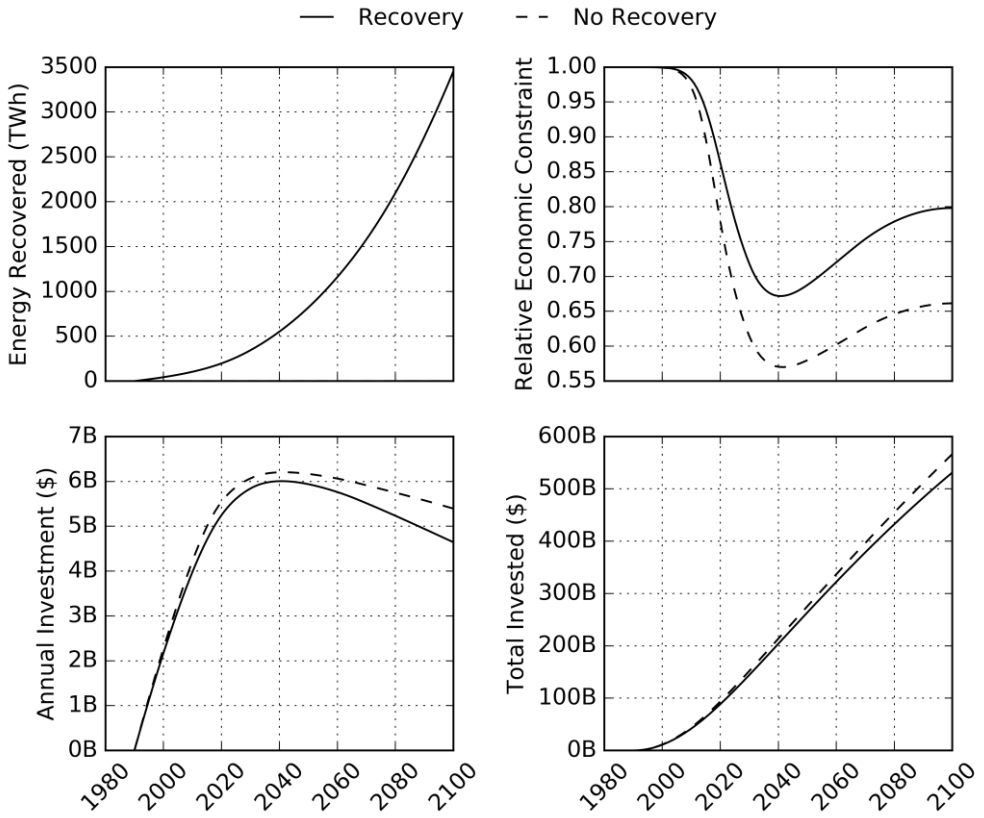
Baseline Parameter Set



Simulated nutrient over-enrichment of (a) Phosphorus, (b) Nitrogen and (c-d) wastewater treatment variables for the period of 1990-2100 using the baseline parameter set

Results

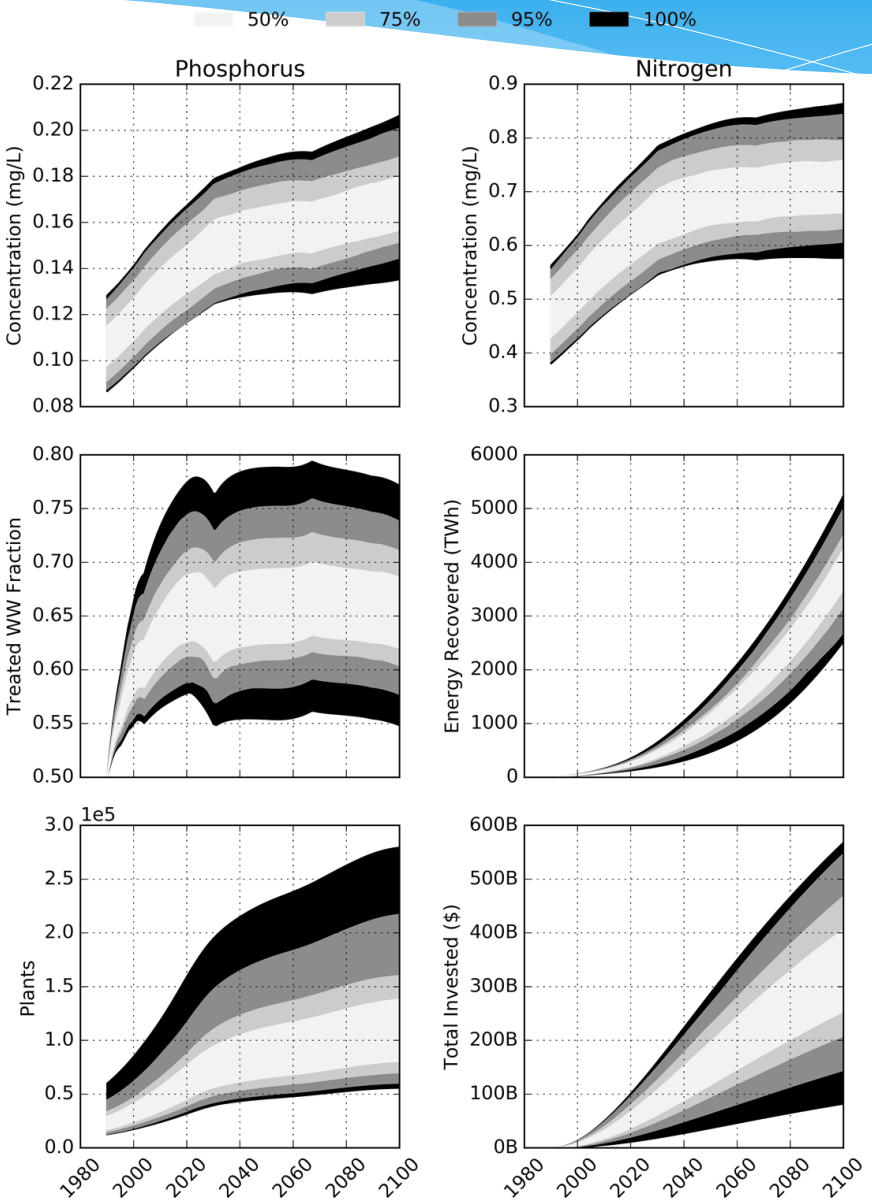
Baseline Parameter Set



Simulated (a) energy recovery and investment variables (b-c) for the period of 1990-2100 using the baseline parameter set

Results

Monte Carlo Analysis



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Conclusions

- Loadings of P and N projected to increase faster than increased treatment can accommodate
- Substantial amount of wastewater energy generation is possible if the technologies become more widely adopted
- Cost offset did not result in a significant reduction in nutrient over-enrichment
- Bottom-up non-point source nutrient management strategies should be implemented